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EDITORS

DAVID B. LELLINGER

C. V. MORTON ROLLA M. TRYON

IRA L. WIGGINS

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American Fern Journal

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American Fern Journal

Vol. 60 January–March, 1970 No. 1

Aberrant Leaves on Angle-Shoots of Selaginella martensii Spring[1]

Terry R. Webster

Dorsal and ventral angle-meristems, which normally develop into roots (Webster and Steeves, 1967), are present at most points of shoot branching in the heterophyllous species *Selaginella martensii* Spring. But in stem segments that are surgically isolated from the intact plant and which are incubated on moist filter paper, these angle-meristems may develop as angle-shoots (Williams, 1937; Webster, 1969) (*Fig. 6*). In a recent study of angle-meristem development in excised stem segments of *S. martensii* (Webster, 1969), most leaves (microphylls) on angle-shoots were normal, according to the description by Harvey-Gibson (1897). But some, particularly those near the base of angle-shoots, were abnormal. The morphology and possible significance of these aberrant leaves is presented in this paper.

Normally, the larger, ventral leaves of the angle-shoots are lanceolate, with a narrow, bluntly pointed apex (*Fig. 1*). The smaller, dorsal ones are ovoid oblique and end in a long, stiff awn (*Fig. 2*).

Both dorsal and ventral leaves possess marginal teeth and are asymmetrical at the base. A single median vascular strand is present, and a ligule occurs at the leaf base on the adaxial surface. Conspicuous rows of stomata occur along the vascular strand (*Fig. 7*).

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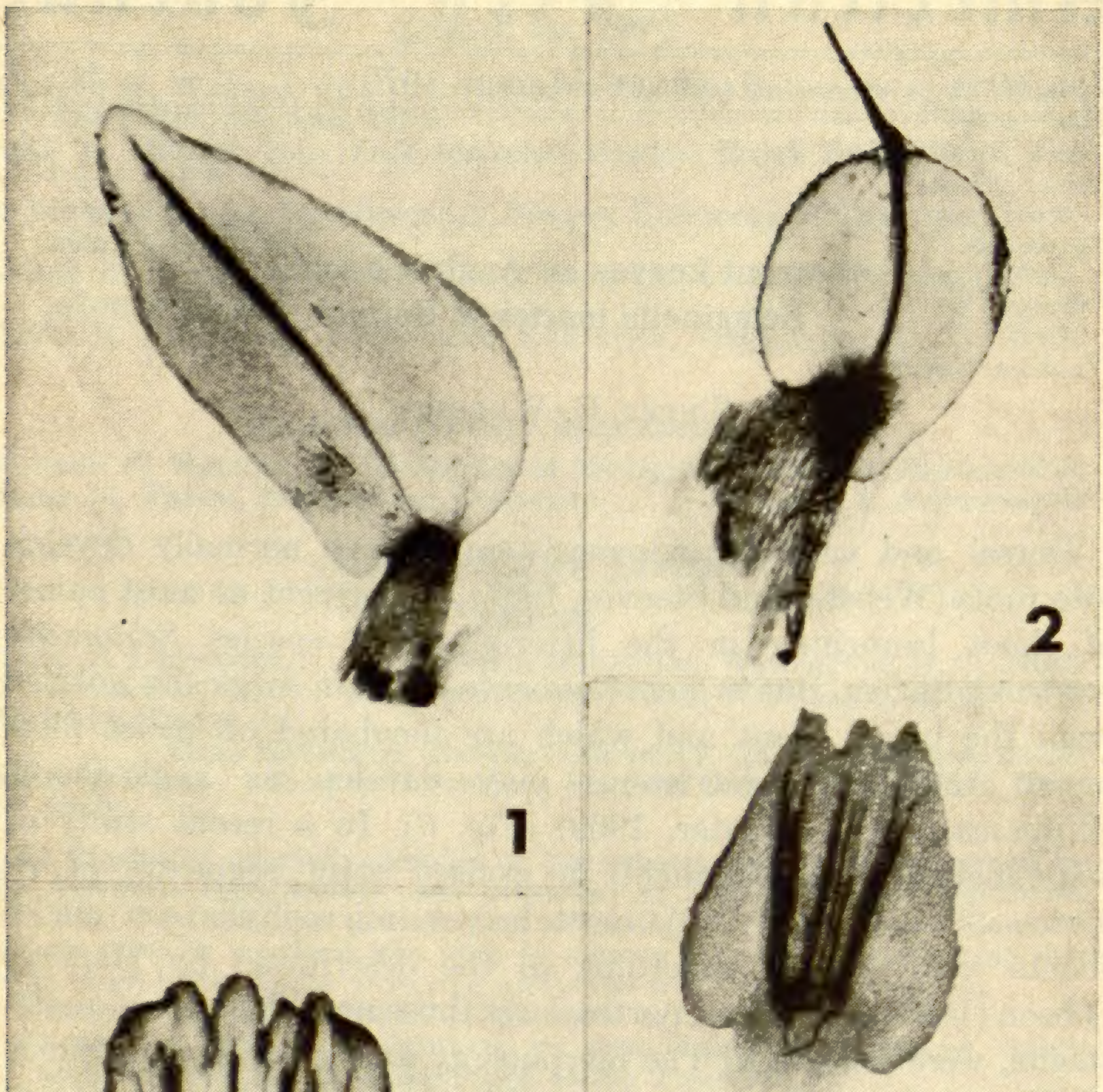
[1] This research was supported by National Science Foundation Grant GB–7068 and by a grant from The University of Connecticut Research Foundation.

Volume 59, No. 4, of the Journal, pp. 137–176, was issued Jan. 14, 1970.



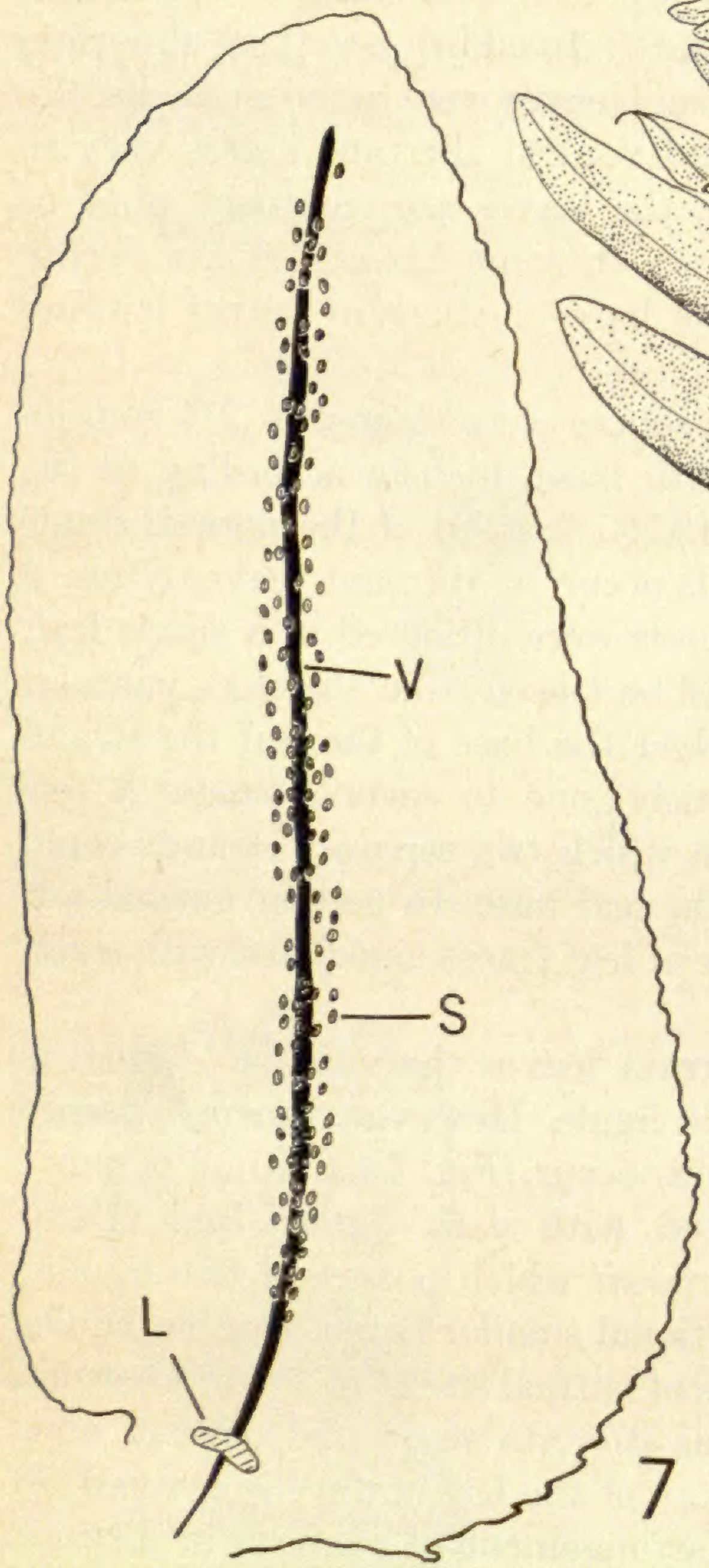
Cleared and Stained Leaves of Selaginella martensii
Angle-shoots Showing Vascular Strands

In contrast to most leaves on angle-shoots, the first few leaves toward the base, proximal to the first branching of the angle-shoot, are aberrant (*Figs. 3, 4,* and *6*). In addition to these abnormal basal leaves, a few cases of unusual leaves were found more distally on angle-shoots. Both dorsal and ventral aberrant leaves vary in shape. Instead of being entire, the leaves are variously lobed or divided at the tip (*Figs. 3* and *4*). In some cases they are deeply cleft. Unlike normal leaves, the base of aberrant leaves is often symmetrical.

For anatomical study, angle-shoots were cleared in 2% sodium hydroxide and were stained with basic fuchsin according to the method described by Jacobs (1952). Instead of the normal single vascular strand, several strands occur in aberrant leaves (*Figs. 3* and *4*). As many as seven strands were observed in a single leaf. In most leaves one strand could be traced from the stem vascular system toward the leaf base. Near the base of the leaf the strand is divided, usually dichotomously, one to several times. A few ventral leaves were observed in which two separate strands could be traced from the stem into the leaf base. In neither normal nor aberrant leaves is the departure of leaf traces associated with a gap in the stem vascular cylinder.

In normal and in most aberrant leaves the vascular system is closely associated with a single ligule. However, in some deeply cleft leaves, two separate ligules occur (*Fig. 5*) and one or more vascular strands are associated with each ligule. Ball (1925) reported sporophylls of *S. martensii* which possessed two ligules, one of normal size and an additional smaller ligule. Double ligules found in the present study were of normal size (*Fig. 5*). In aberrant leaves each vascular strand has stomata associated with it, and, compared to normal leaves, more of the leaf surface is covered by stomata (*Figs. 7* and *8*). The arrangement of stomata in distinct rows is not so evident as in normal leaves.

FIG. 1. NORMAL VENTRAL LEAF, × 23. FIG. 2. NORMAL DORSAL LEAF, × 22. FIG. 3. ABERRANT VENTRAL LEAF, × 46. FIG. 4. ABERRANT DORSAL LEAF, × 42. FIG. 5. ABERRANT DORSAL LEAF WITH TWO LIGULES. SOME STEM TISSUE VISIBLE THROUGH LEAF, × 47.



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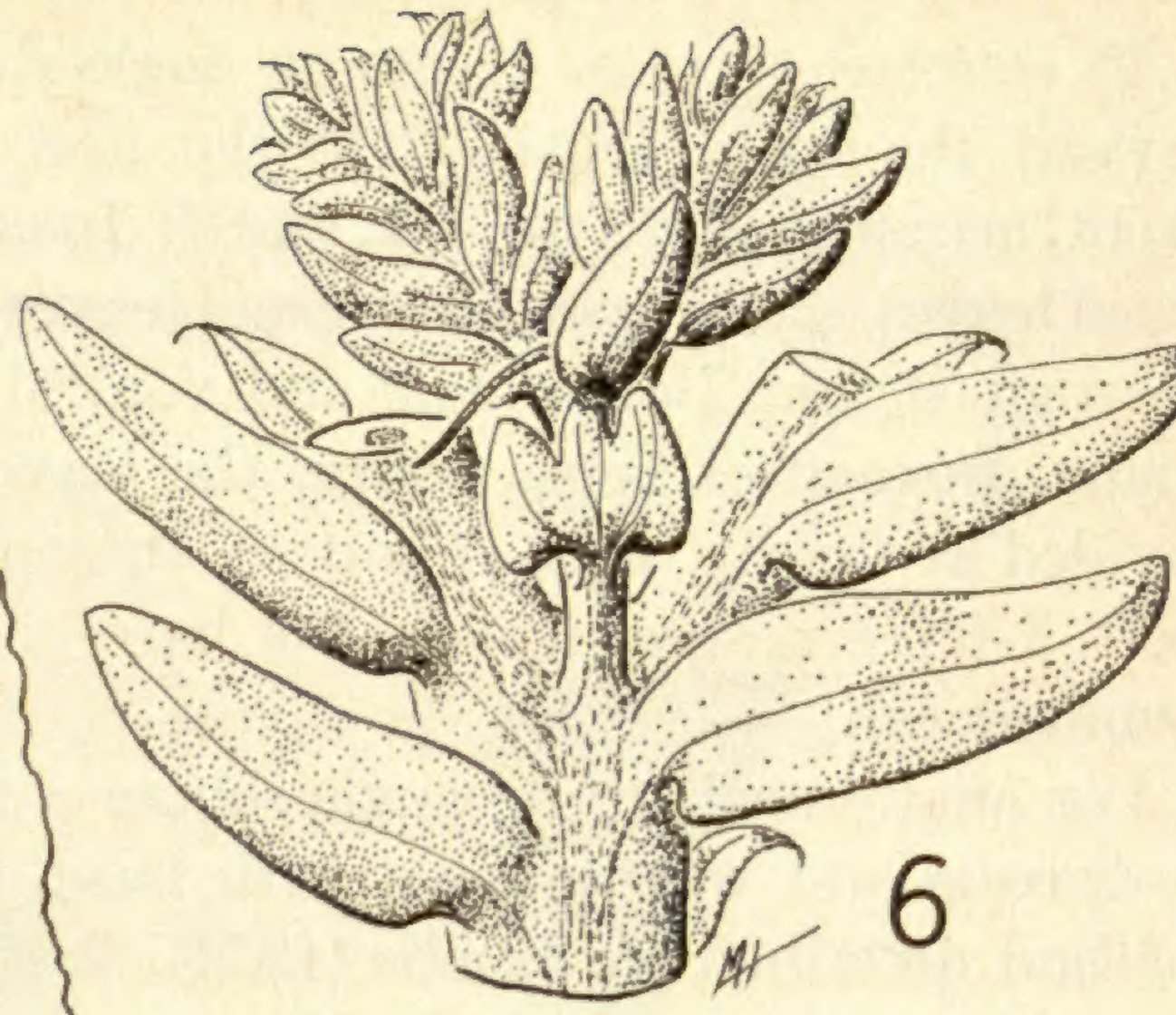

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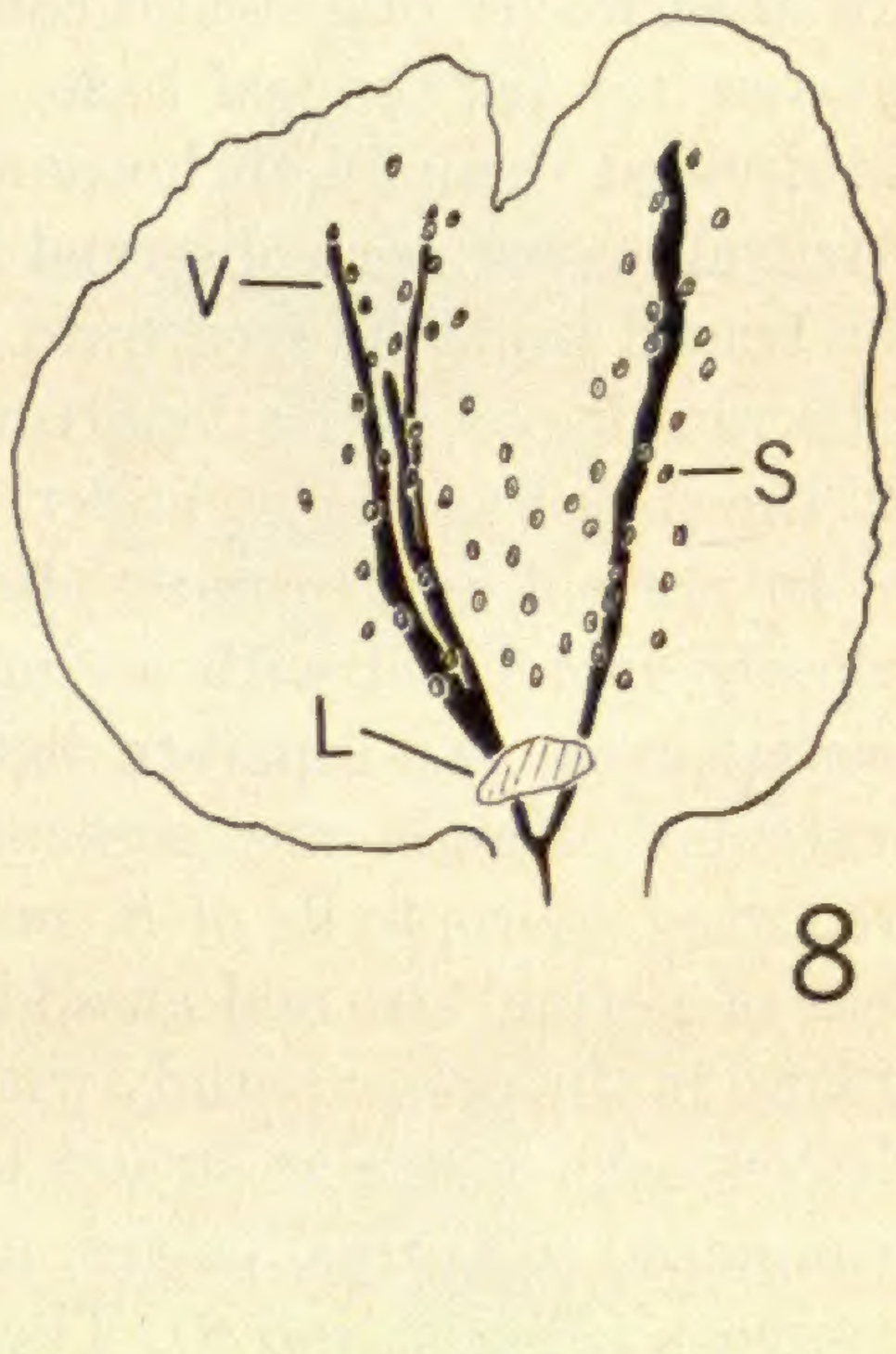

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PLATE 2. FIG. 6. DIAGRAM OF VENTRAL VIEW OF STEM SEGMENT BEARING AN ANGLE–SHOOT. NOTE SINGLE ABERRANT VENTRAL LEAF WITH BRANCHED VASCULATURE TOWARD BASE OF ANGLE-SHOOT. FIG. 7. STOMATA ON NORMAL LEAF FROM MAIN SHOOT. FIG. 8. STOMATA ON ABERRANT LEAF FROM ANGLE–SHOOT. The abbreviations are: L = LIGULE. S = STOMA, V = VASCULAR STRAND.

DISCUSSION

Grambast and Rosello (1965) described leaves of *S. willdenovii* (Desv.) Baker in which there were two or three veins from the dichotomous branching of a single vascular trace. According to their illustrations, the leaves themselves were not so distinctly lobed or divided as the aberrant leaves described here in *S. martensii*. The authors made no mention of stomata or ligules in the leaves of *S. willdenovii*, but they did discuss possible phylogenetic implications of the branched vasculature. They cited fossil lycopods (*Protolepidodendron* Krejci, *Duisbergia* Kräus. and Weyl., and *Sigillaria scutellata* Brongn.) which possessed leaves with dichotomously branched vascular strands, and suggested that in *S. willdenovii* microphylls with dichotomizing veins represent a primitive condition. According to their view, microphylls with a single vein could have been derived by reduction. They suggested that, like megaphylls, microphylls may, in some cases, have been derived from a system of axes.

One could apply a similar interpretation to the microphylls of *S. martensii*. Aberrant leaves with branched vasculature could be interpreted as representing a primitive condition, and normal leaves with a single vascular strand a more advanced condition. A comparison of normal and aberrant leaves would suggest that during evolution lobing, number of vascular strands, and rows of stomata were reduced.

According to the theory of recapitulation (ontogeny, in abbreviated fashion, repeats phylogeny), the position of leaves on angle-shoots could be used to indicate a primitive or an advanced condition. Although usually applied to progressive development from juvenile to adult leaves in sporelings or seedlings, Takhtajan (1959, p. 91) has applied this theory to leaves occurring on accessory shoots. Angle-shoots would fit into this latter category. According to the theory, the progression of microphylls in angle-shoots represents at least some stages in the evolution of microphylls for *S. martensii*. Thus aberrant leaves occurring at the base of angle-shoots would represent a primitive condition, and more distal (normal) leaves an advanced condition (*Fig. 6*). However,

as Foster and Gifford (1959, p. 9) have stated, whether juvenile leaves provide reliable evidence to the morphology of ancestral leaf types is questionable, and hypotheses based on the theory of recapitulation should always be made with great caution. It should also be noted that the features found in aberrant leaves of *S. martensii* are not known in fossil representatives of *Selaginella* or in *Selaginellites*. At the present time there is no strong evidence to indicate that aberrant microphylls in *Selaginella* do in fact represent a primitive condition. Rather than having any phylogenetic significance, the aberrant leaves in *S. martensii* merely may be the result of abnormal development during the early ontogeny of angle-shoots.

LITERATURE CITED

BALL, N. G. 1925. On the occurrence of a double ligule in Selaginella martensii. Ann. Bot. **39**: 884.

FOSTER, A. S. and GIFFORD, E. M. 1959. Comparative Morphology of Vascular Plants. W. H. Freeman, San Francisco.

GRAMBAST, L. and S. ROSELLO. 1965. Les notions de microphylle et de mégaphylle et leur signification phylogénétique. Compt. Rend. Acad. Sci., Paris **261**: 5183–5186.

HARVEY–GIBSON, R. J. 1897. Contributions towards a knowledge of the anatomy of the genus Selaginella Spr. III. The leaf. Ann. Bot. **11**: 123–155.

JACOBS, W. P. 1952. The role of auxin in differentiation of xylem around a wound. Amer. J. Bot. **39**: 301–309.

TAKHTAJAN, A. L. 1959. Essays on the evolutionary morphology of plants. (Transl. by O. H. Gankin) Amer. Inst. Biol. Sci., Washington, D.C.

WEBSTER, T. R. 1969. An investigation of angle–meristem development in excised stem segments of Selaginella martensii. Canad. J. Bot. **47**: 717–722.

———, and T. A. STEEVES. 1967. Developmental morphology of the root of Selaginella martensii Spring. Canad. J. Bot. **45**: 395–404.

WILLIAMS, S. 1937. Correlation phenomena and hormones in Selaginella. Nature **139**: 966.

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A Further Note on the Type of Platycerium alcicorne

C. V. MORTON

Several years ago I published a paper, "The Nomenclature of a Madagascarian Platycerium" (Morton, 1964), in which I concluded that *Acrostichum alcicorne* Swartz (Syn. Fil. 12, 196. 1806) was an illegitimate change of name for *Acrostichum stemaria* Palisot (Fl. d'Oware et Bénin 3: *t. 2.* 1805), which was cited by Swartz as a synonym. This was an error on my part, occasioned by the fact that nowhere in the "Index Filicum" or in Willdenow or Desvaux is there any indication that Swartz had published his *Acrostichum alcicorne* prior to 1806. Mr. De Joncheere was the first to note that the name *A. alcicorne* Swartz was actually published in Schrader's "Journal für die Botanik," (1800, vol. 2, part 1, p. 11. 1802).[1] Since this 1802 publication is prior to the publication of *A. stemaria* Palisot it is clear that *A. alcicorne* Swartz was not a renaming of *A. stemaria*, and must therefore have a different type.

Swartz' 1802 paper "Genera et Species Filicum" is a sort of preliminary to his extensive "Synopsis Filicum" of 1806; it is very brief throughout, with short diagnoses and no citation of specimens, localities, or synonymy in general. In the case of *A. alcicorne* Swartz did cite "*Neuroplatyceron* Pluk. am. phyt. *t. 429, f. 2.*" De Joncheere (1967) has argued that this Plukenet plate must be taken as the lectotype of *A. alcicorne*. However, it was not Swartz' habit to give names indiscriminately, if ever, to plants known to him only from pre-Linnaean drawings. In this case there is ample evidence that the protologue included not only this pre-Linnaean plate of Plukenet but also herbarium material, for Swartz described the fertile fronds, which were not depicted by Plukenet. In cases like this there is general agreement that species ought to be typified by specimens when possible and not by plates.

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[1] The date "1801" on the title page has usually been accepted, but Stafleu in his "Taxonomic Literature," p. 432. 1967, has shown that this part was published in March, 1802.

Lectotype of Acrostichum alcicorne, nest leaves (UPS)

Dr. Schelpe searched the herbarium in Stockholm and could not find a specimen suitable for a lectotype, and De Joncheere stated that Schelpe also searched the herbarium in Uppsala without finding any specimens. At my request, Dr. John Wurdack recently found that there are indeed specimens in Uppsala, and through the courtesy of Dr. Rolf Santesson I now have these on loan. The specimens mentioned are in the original herbarium of Afzelius. They are fine specimens, including nest-leaves and fertile leaves, mounted on five sheets. They are indicated as being from Sierra Leone collected by Smeathman. In his 1806 publication Swartz mentions (p. 196) collections from Madagascar, *Commerson;* Oware, *Palisot*; Java, *Thunberg*; Guinea, *Afzelius*; and Nova Hollandia, *Née*," and on p. 12 cites "Sierra Leone" as one of the localities. In this 1806 publication Swartz had added as synonyms *A. stemaria* Palisot and *A. bifurcatum* Cav., and it is likely that the collections of Commerson and Palisot were cited from Palisot rather than actually seen by Swartz and that the Née collection was cited from Cavanilles. No specimen from Java collected by Thunberg has been found. The Afzelius collection from Sierra Leone mentioned above is the only herbarium specimen that can definitely be associated with a collection cited by Swartz. The name *alcicorne* is in the hand of Swartz. The five sheets in the Uppsala Herbarium are here designated as the lectotype of *A. alcicorne* Swartz. According to Schelpe, there is a specimen in Stockholm from Sierra Leone annotated by Wikström as *A. alcicorne*, and this is doubtless an isolectotype, although Afzelius is not definitely indicated as the source.

The specimens from Sierra Leone designated as lectotype are identical with *A. stemaria* Palisot from Oware [Nigeria], the type of which I have seen in Paris. The Plukenet plate was apparently drawn from a specimen now in the Sloane Herbarium in the British Museum, and according to De Joncheere came from the Comoro Islands and is identical with the plant described as *Acrostichum alcicorne* Willemet, now properly *Platycerium vassei* Poisson. The lectotype chosen above agrees well enough with Swartz'

Lectotype of Acrostichum alcicorne, fertile frond (UPS)

brief diagnosis, at least as well as that diagnosis agrees with *P. vassei*.

The present lectotypification is really best for stability as well as fully justified by the facts. Although *A. alcicorne* Swartz was prior to *A. stemaria* Palisot by three years, it was itself illegitimate, being a later homonym of *A. alcicorne* Willemet (1796), a species based on an entirely different type (Madagascar, *Stadtmann*). The next earliest name for the West African species is thus *A. stemaria* Palisot, and the correct name for it is *Platycerium stemaria* (Palisot) Desv., of which *P. alcicorne* (Swartz) Desv. is thus a taxonomic synonym. This is a fortunate turn of events, since *P. stemaria* is a name well known among horticulturists. Incidentally, Dr. Schelpe has suggested in a letter to Barbara Joe that the epithet "stemaria" ought to be corrected to "stemmaria," since the root is from "stemma," a garland, in Greek. This may well be, but the correction of the original spelling of a name ought not to be made for purely etymological reasons if there is no reason to suspect a purely typographical error; there are many poorly or wrongly formed names that must nevertheless be accepted.

The name *P. alcicorne* Desv. adopted by De Joncheere for the East African and Madagascarian species is thus incorrect, which is fortunate, since this epithet has been widely misapplied to three different species—the West African *P. stemaria*, and the East African and Madagascarian *P. vassei*, and the Australian *P. bifurcatum*.

Another species of *Platycerium* that may be mentioned here incidentally is *P. angolense* Welw. ex Baker in Hook & Bak. Syn. Fil. 425. 1868. The name appears as a comment under *P. aethiopicum* Hook. as follows: "Dr. Welwitsch has furnished us with a plant (P. angolense Welw. MSS.) which is most like this, but has a broad-cuneate fertile frond 9 in. br. at the top, without either forks or horns, and with a patch of fruit nearly as broad as the lamina." Dr. Schelpe has suggested in a letter to me that this name ought to be rejected by Art. 34 of the Code as not being accepted by the publishing author. In my opinion it is valid, as valid as a

large number of other names that are published rather casually in footnotes or text-notes. Baker did not either definitely accept it or reject it. He certainly did not conclude that it was exactly the same as *P. aethiopicum*, but gave its differences as he saw them. Since there is a name and a description, the name ought to be accepted as validly published. As it turns out, Welwitsch was quite right that it was different from *P. aethiopicum* Hooker, and *P. angolense* Welw. ex Baker is the correct name for the third African species of *Platycerium*, the other two being *Platycerium stemaria* and *P. vassei*; a taxonomic synonym of *P. angolense* is *P. elephantotis* Schweinf. and another probable synonym is *P. velutinum* C. Chr., as discussed by Barbara Joe (1964) in her useful review of *Platycerium*.

LITERATURE CITED

JOE, BARBARA. 1964. A review of the species of Platycerium (Polypodiaceae). Baileya **12**: 69–126.

JONCHEERE, G. J. DE. 1967. Notes on Platycerium Desv. I. Nomenclature and typification of the genus and species in Desvaux's original publication of 1827. Blumea **15**: 441–451.

MORTON, C. V. 1964. The nomenclature of a Madagascarian Platycerium. Baileya **12**: 36–38.

NATIONAL MUSEUM OF NATURAL HISTORY, WASHINGTON, D. C. 20560.

Gametophyte Ontogeny and Sex Expression in *Dryopteris ludoviciana*[1]

MICHAEL I. COUSENS AND HARRY T. HORNER, JR.

Although the ontogeny of fern gametophytes has a long history of morphological investigation, sex expression in ferns has only recently been studied by experimental morphologists and geneticists. Most homosporous ferns have bisexual gametophytes whose mitotically derived gametes produce a completely homozygous sporophyte after selfing (Klekowski and Baker, 1966). Wilkie's work (1956), which demonstrated self incompatibility in *Pteridium aquilinum*, has stimulated the use of fern gametophytes in genetic research. Klekowski and his associates (1968, 1969) used genetic and morphological criteria to characterize pteridophyte gametophytes in terms of their probability for intragametophytic (functionally bisexual) and intergametophytic (functionally unisexual) mating.

This study was undertaken to determine whether the ontogeny of *Dryopteris ludoviciana* (Kunze) Small gametophytes differed from that reported for other dryopterid and thelypterid gametophytes (Kny, 1895; Waldemann, 1928; Nayar and Chandra, 1963), and to determine sex expression under controlled conditions. The effect of population density on sex expression was tested by culturing single isolated gametophytes and gametophytes in moderate and dense populations. The ontogeny and sex expression of *Thelypteris dentata* (Forsk.) E. St. John was also observed for comparison.

METHODS AND MATERIALS

Dryopteris ludoviciana occurs in cypress and gum swamps, as well as in lime sinks, from Florida west along the Gulf Coast to Louisiana and north as far as North Carolina (Brown and Correll,

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[1] This paper is a portion of a thesis completed by the senior author for the Master of Science Degree, I. S. U., 1969.

1942). A detailed record of its occurrence is not available, but it is less common than other *Dryopteris* species.

Two *Dryopteris ludoviciana* sporophytes were greenhouse-grown after their collection on November 20, 1966, in Alachua County, Florida, in the Devil's Millhopper, a lime sink 5–6 miles northwest of downtown Gainesville. A voucher specimen (*John T. Mickel 1730*) is in the Iowa State University Herbarium. The plants used in this study were diploid ($2n = 82$) (A. R. Smith, pers. comm.).

Fertile pinnae were cut from vigorous fronds and rinsed in running distilled water to remove foreign spores. The pinnae were then sealed in small manila envelopes. After most of the sporangia had dehisced (8–12 days at 20°C) the spores were transferred to small corked vials and utilized within two months.

All spores were sown on a sterile mixture of loam and coarse sand (4:1). Varying numbers of spores were sown to produce different densities. Population density was determined by counting all gametophytes visible at 30×. The average number of gametophytes per cm^2 was then determined. Dense populations contained 10–21 gametophytes per cm^2 and moderate populations had 1–3 per cm^2. Isolated spores were cultured in small petri dishes.

Culture vessels containing only sterile soil were opened for watering and observation with the same frequency as the experimental cultures. Fern gametophytes appearing in these cultures reflected the extent of contamination (about one per cent). Densely sown cultures of *Thelypteris dentata* were also maintained under the same conditions of culture as *Dryopteris ludoviciana* and later were surveyed for the occurrence of gametangia.

Conditions of culture, including the use of soil as a substrate (Atkinson and Stokey, 1964), were selected to approximate the habitat of naturally occurring fern gametophytes. The cultures were maintained in a Percival growth chamber. Diffuse illumination was provided by white fluorescent tubes and incandescent bulbs at an intensity of 350–400 ft-c. Temperature at the soil surface was maintained at 22°C during the 12 hr light and 12 hr dark periods.

Samples of 24 or more gametophytes were removed for observation of development and sex expression at 25, 35, 45, 58, 72, and 111 days after sowing. An effort was made to select gametophytes representative of all sizes and stages. The gametophytes were placed in a petri dish or on a glass slide containing 1.75% lactose solution for microscopic examination. This medium prevented plasmolysis for 8–12 hours and did not hinder the dehiscence of antheridia or the motility of sperms.

GAMETOPHYTE ONTOGENY AND GAMETANGIA

Spores of *Dryopteris ludoviciana* are bilateral with a prominent perispore. A spring-collected sample (April to June) of 162 spores ranged from 24–50 μ long by 16–33 μ wide. One hundred and eight fall-collected spores (October) ranged from 21–54 μ long by 16–37 μ wide. The spring-collected spores averaged 36 $\times$ 24 μ and the fall-collected spores averaged 36 $\times$ 26 μ. Spore size was considerably less uniform in the fall collection (*Fig. 1*), but the biological significance of this, if any, is not known. A bimodal distribution of spore size was not found.

Most spores germinated within 6–20 days, but some took as long as three months. The spore coat ruptured irregularly or along the ridge and remained attached to the basal cell (*Fig. 2*). The first rhizoid was delimited shortly after germination, and a second rhizoid sometimes formed before filamentous growth began (*Fig. 3*). Successive divisions then produced a 4–6-celled filament which was either stout (*Fig. 4*) or elongate (*Fig. 5*). Filamentous growth was prolonged if a spore germinated in a soil crevice, or was otherwise shaded (*Fig. 7*). These attenuated filaments eventually became planate.

Longitudinal or oblique divisions in the terminal cell of the filament initiated planate growth (*Fig. 6*). These divisions could occur when the filament was only two or three cells long (*Fig. 8*). Subsequent longitudinal divisions could occur in all but the basal cell of the filament, obscuring the earlier filamentous form (*Fig. 9*).

Continued divisions in two dimensions were most frequent distally, producing a triangular gametophyte of 10–15 cells with

marginal trichomes (*Figs. 11, 12*). This stage was occasionally irregular (*Fig. 10*), but these irregularities were obscured by subsequent symmetrical growth. The fastest growing gametophytes established an apical cell 12–16 days after germination (*Fig. 13*; *Table I*). Slower growing gametophytes reached this stage within 16–30 days. The apical cell cut off derivatives laterally to produce the notch meristem 14–32 days after germination (*Figs. 14, 15*; *Table I*). Once this stage was reached, irregularities in growth were rare, and all gametophytes, except ameristic males which lack a notch meristem, became cordate (*Fig. 16*).

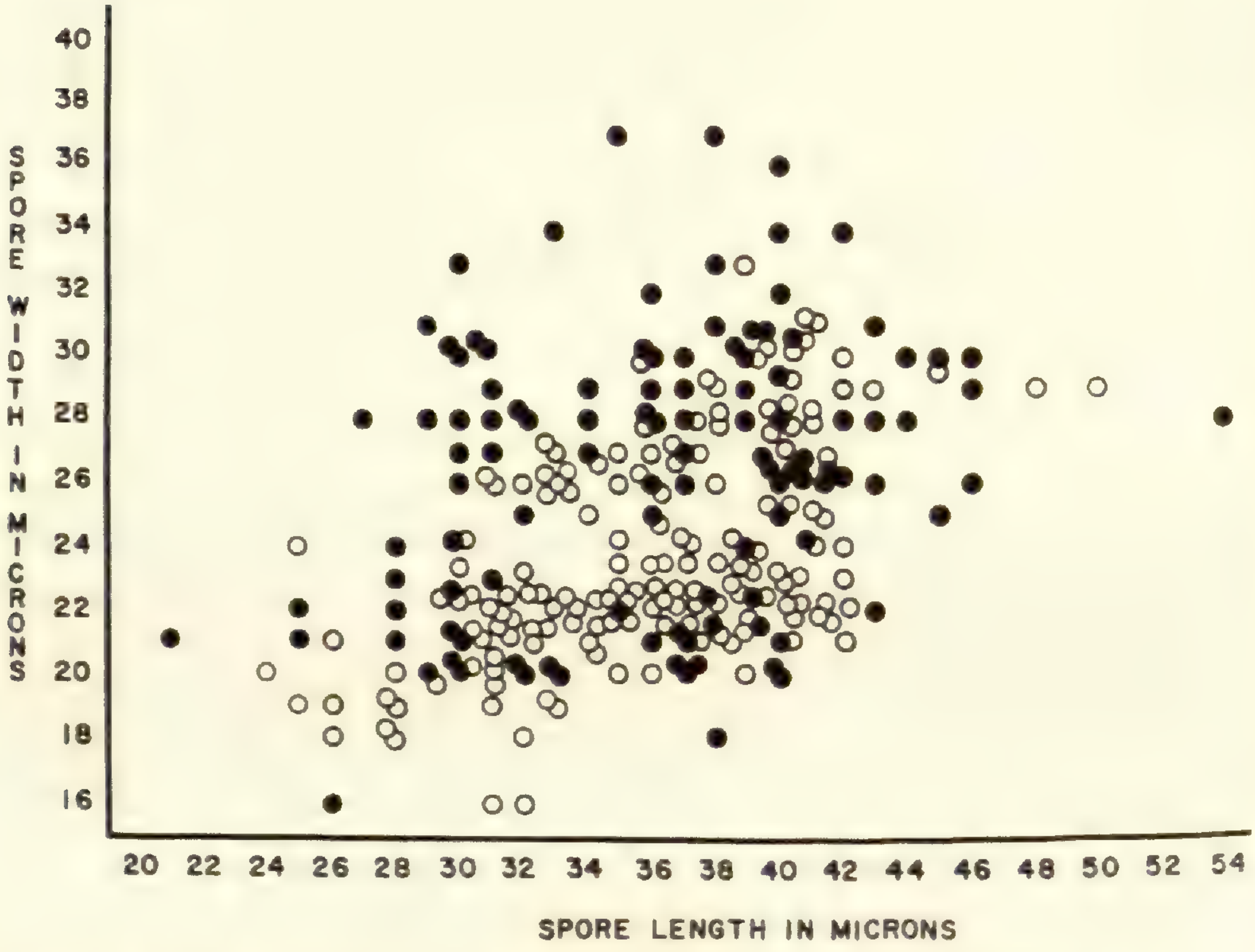


FIG. 1. SIZE DISTRIBUTION OF DRYOPTERIS LUDOVICIANA SPORES. ○ = ONE SPRING–COLLECTED SPORE; ● = ONE FALL–COLLECTED SPORE.

Trichomes were common on the dorsal surface, averaging one trichome per five prothallial cells. This ratio diminished to one

trichome per fifteen prothallial cells on the wings and to one per 20–30 prothallial cells on the ventral surface.

Gametophytes 20–45 days old and 0.5–0.7 mm wide initiated a cushion which was two or three cells thick at first and later four or five cells thick. Lateral prothallial cells (*Fig. 20*) became much larger than younger anterior cells (*Fig. 19*). Older gametophytes were 0.9–13.0 mm wide (*Figs. 17, 21*), depending on their pattern of sex expression.

TABLE I. INITIATION (IN DAYS AFTER GERMINATION) OF THE STAGES OF DEVELOPMENT OF DRYOPTERIS LUDOVICIANA GAMETOPHYTES.

Developmental stage	*Rapidly growing gametophyte*	*Slow growing gametophyte*
Filamentous	6	6
First longitudinal division	7	7
Early planate (9–15 cells)	8–11	11–29
Apical cell	12–16	17–30
Notch meristem	14–19	20–32
Cushion initiation	20–26	27–45

The antheridia are of the polypodioid type (Atkinson and Stokey, 1964), consisting of a single basal cell, a cylindrical middle cell which surrounds the central primary androgonial cell, and an undivided cap cell.

The archegonia are of the advanced type (Atkinson and Stokey, 1964) with four or five tiers of neck cells, each tier containing four cells. The central canal cell was binucleate and enlarged distally. The archegonium was slightly larger at its apex than at its base and was always inclined slightly toward the base of the gametophyte. Archegonia occurred ventrally on a broad area just behind the notch, and up to 80 occurred on gametophytes 8–13 mm wide.

SEX EXPRESSION IN POPULATIONS

Dryopteris ludoviciana has a normal sexual alternation of generations. The gametophytes observed in isolated, moderate,

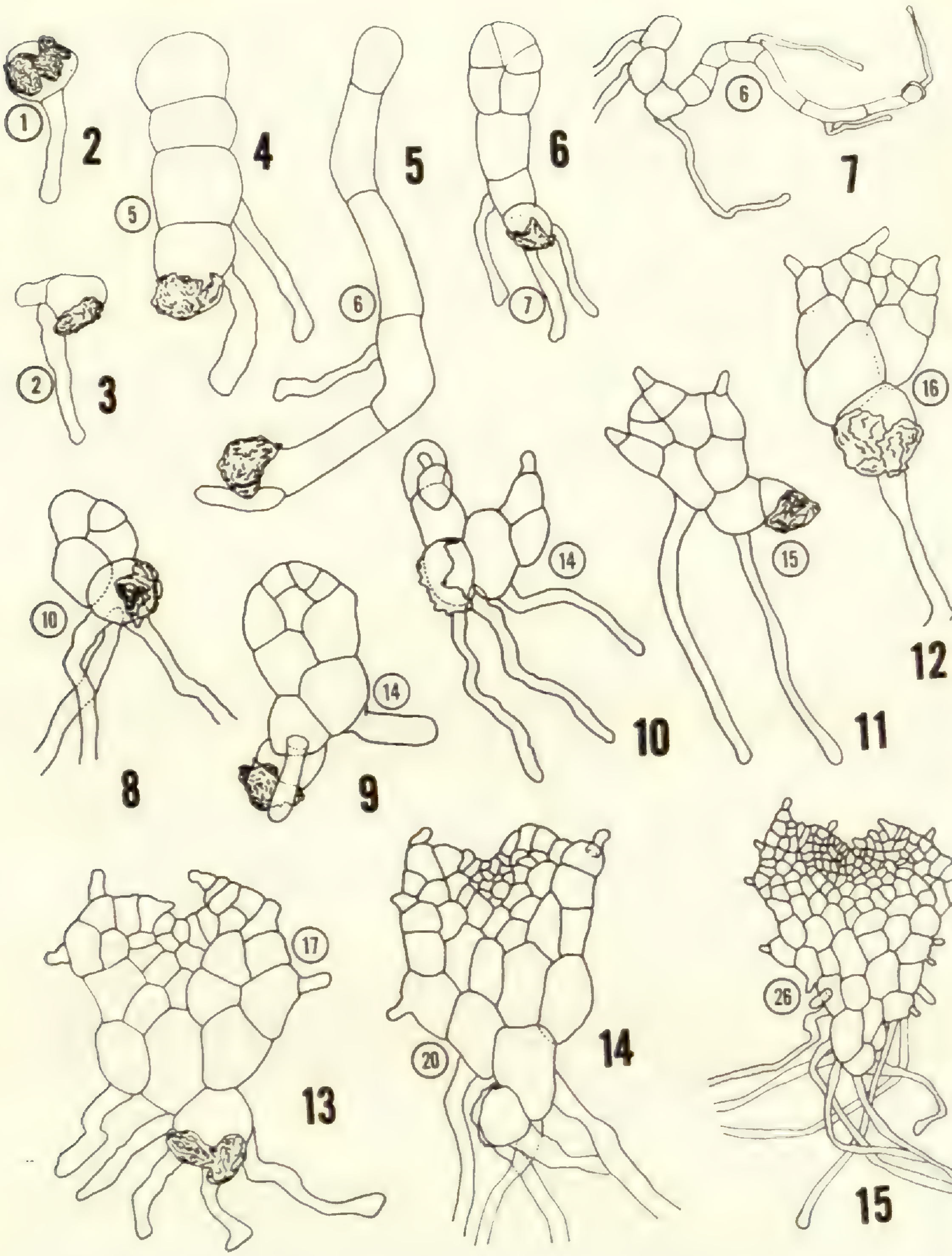


Plate 5. Early Ontogeny of D. ludoviciana Gametophytes. The numbers in circles indicate days after germination. The most common sequence of development is Figs. 2, 4, 6, 11–15. One cm = 100 μ for Figs. 7, 15; 1.5 cm = 100 μ for all other figures.

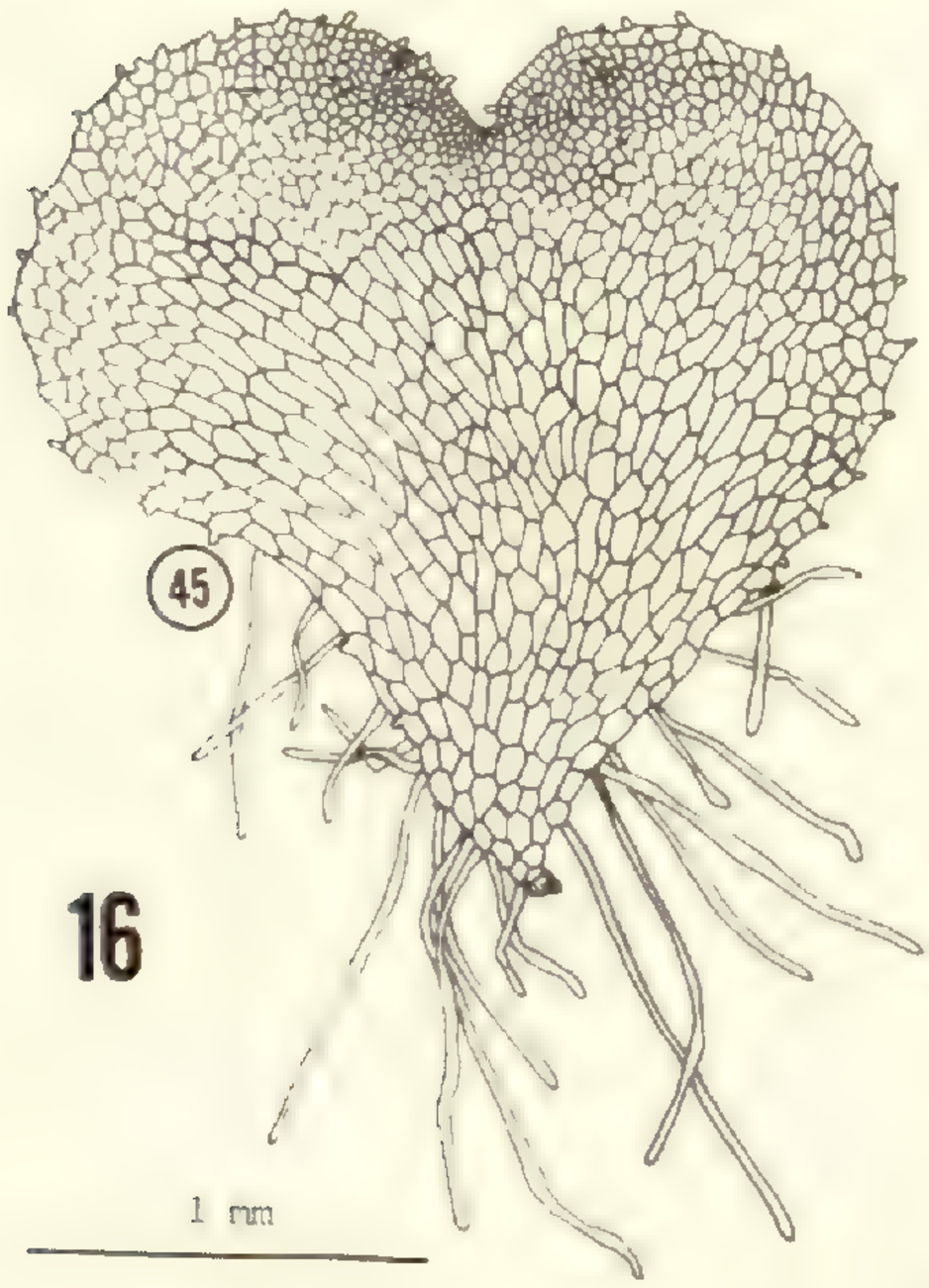
and dense cultures expressed one of five possible patterns of sexuality, or lacked gametangia. The five sex expression patterns were based on the presence of one or both types of gametangia, and, where both kinds of gametangia occurred, the sequence of their appearance. The presence or absence of a notch meristem was also recorded for all gametophytes.

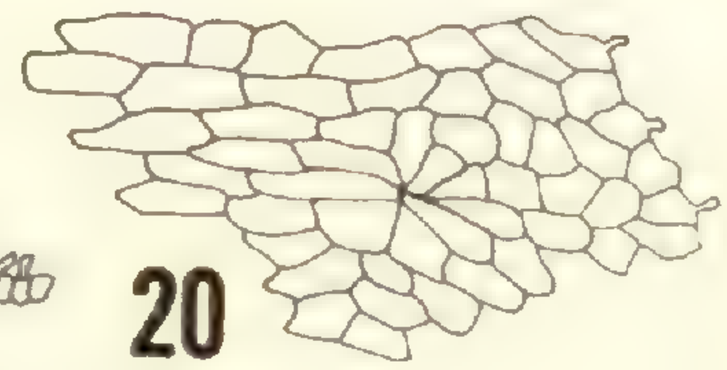
Rapidly growing gametophytes (*Table I*) usually became *unisexual females* and were the first plants in all populations to become sexual (*Fig. 18*). Archegonial initials were found on 24-day-old gametophytes as small as 0.9 mm wide. These gametophytes continued to grow and produce additional archegonia, attaining an average width of 4.6 mm 45 days after germination (*Fig. 21*). These gametophytes remained unisexual after 105 days and became 8–13 mm wide (*Fig. 17*). Older gametophytes occasionally produced basal outgrowths which became antheridial.

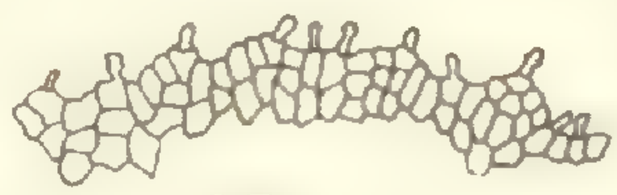
Protandrous bisexual gametophytes are typical of most homosporous leptosporangiate ferns (Atkinson and Stokey, 1964), but were rare in *D. ludoviciana* populations studied here. These gametophytes first produced antheridia among the rhizoids and on the basal half of the cushion. Six to 20 days later archegonia formed below the notch meristem. Antheridia numbered fewer than 80 on protandrous bisexual gametophytes. Twenty of the 527 gametophytes surveyed were protandrous bisexual.

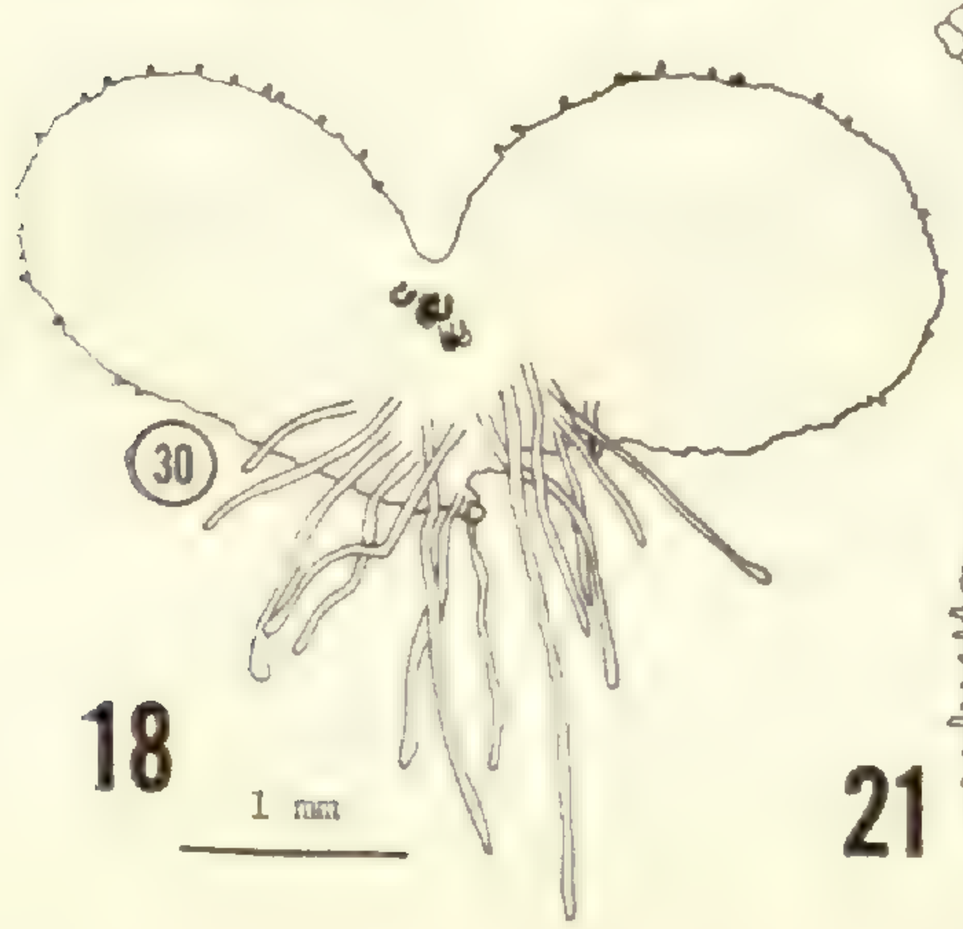
In *synchronous bisexual* gametophytes archegonia occurred in the typical position below the notch meristem and antheridia were restricted to the distal half of the cushion adjacent to and among the archegonia. Maturation of both kinds of gametangia was synchronous, so that the periods of antheridial dehiscence and archegonial receptivity overlapped. These gametophytes first became sexual 30–40 days after germination and continued to produce both kinds of gametangia. After 45 days a gametophyte bore an average of ten archegonia and 22 antheridia.

Ameristic male gametophytes developed antheridia precociously but failed to develop an organizing notch meristem. They became sexual shortly after germination, producing antheridia on almost every cell, and occasionally two per cell. Ameristic males devel-









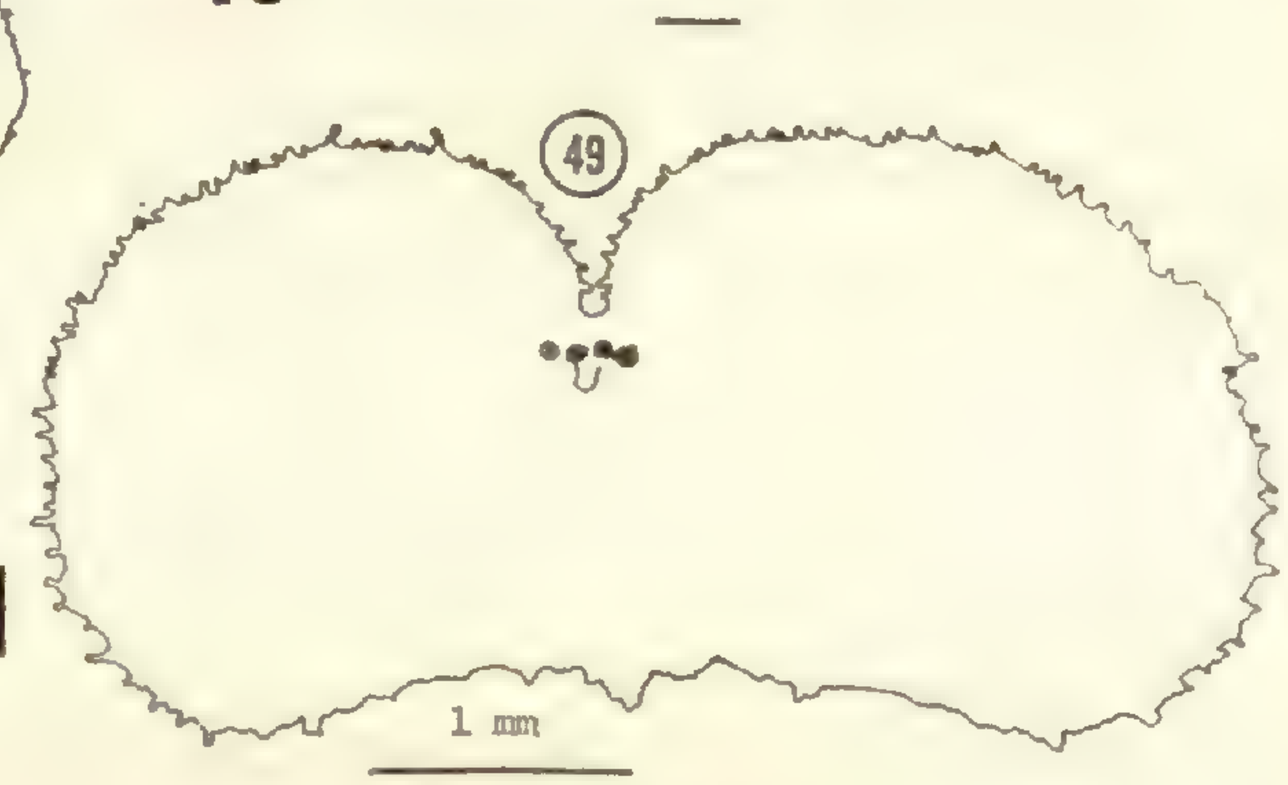


Plate 6. Late Ontogeny of D. ludoviciana Gametophytes. The numbers in circles indicate days after germination. Fig. 16. Slow growing gametophyte with cushion but without gametangia. Fig. 17. Unisexual female gametophyte with overlapping wings anterior to notch; archegonia not illustrated. Fig. 18. Rapidly growing gametophyte with archegonia. Fig. 19. Cells from anterior margin of wing; cf. Fig. 20. Fig. 20. Cells from lateral area of Fig. 21. Fig. 21. Rapidly growing unisexual female gametophyte.

oped only from spores which either remained within sporangia, were next to sporangial fragments, or were in contact with the rhizoids of older gametophytes. Their form varied from filamentous to spathulate.

	SEXUALITY	SPRING			FALL		
		Per cent of total	Sample size	Average size mm	Per cent of total	Sample size	Average size mm
		25 35 45	25 35 45	25 35 45	25 35 45	25 35 45	25 35 45
ISOLATED	FEMALE	28 - 75	34 - 6	1.9 - 2.6	43 60 80	13 18 20	1.6 3.3 6.1
	PROTANDROUS BISEXUAL	0 - 0	0 - 0	- - -	0 0 0	0 0 0	- - -
	SYNCHRONOUS BISEXUAL	1 - 12	2 - 1	2.1 - 3.6	0 23 8	0 7 2	- 3.9 6.3
	AMERISTIC MALE	0 - 0	0 - 0	- - -	0 0 0	0 0 0	- - -
	MERISTIC MALE	0 - 0	0 - 0	- - -	0 0 0	0 0 0	- - -
	GAMETANGIA ABSENT	71 - 13	90 - 1	0.4 - 4.0	57 17 12	17 5 3	0.4 0.5 0.8
	TOTALS	100 - 100	126 - 8	- - -	100 100 100	30 30 25	- - -
MODERATE	FEMALE	- - -	- - -	- - -	34 40 39	10 14 11	1.5 2.9 3.7
	PROTANDROUS BISEXUAL	- - -	- - -	- - -	0 0 -	0 - -	- - -
	SYNCHRONOUS BISEXUAL	- - -	- - -	- - -	7 28 36	2 10 10	1.8 2.5 3.1
	AMERISTIC MALE	- - -	- - -	- - -	0 0 0	0 - 0	- - -
	MERISTIC MALE	- - -	- - -	- - -	11 2 0	3 1 0	0.6 1.4 -
	GAMETANGIA ABSENT	- - -	- - -	- - -	48 30 25	15 11 7	0.5 0.3 0.9
	TOTALS	- - -	- - -	- - -	100 100 100	30 36 28	- - -
DENSE	FEMALE	43 - 30	21 - 22	5.3 - 3.6	40 30 32	29 27 26	2.4 3.0 3.5
	PROTANDROUS BISEXUAL	0 - 2	0 - 2	- - 3.5	0 0 1	0 0 1	- - 5.0
	SYNCHRONOUS BISEXUAL	0 - 0	0 - 0	- - -	8 15 22	6 13 18	2.7 3.1 3.9
	AMERISTIC MALE	14 - 12	7 - 9	0.8 - 0.6	0 0 0	0 0 0	- - -
	MERISTIC MALE	33 - 20	16 - 14	1.7 - 1.5	20 28 36	14 25 29	0.8 0.6 0.9
	GAMETANGIA ABSENT	10 - 36	5 - 26	2.0 - 2.5	32 27 9	23 24 7	0.6 0.6 0.5
	TOTALS	100 - 100	49 - 73	- - -	100 100 100	72 89 81	- - -

TABLE II. SEX EXPRESSION IN 25, 35, AND 45-DAY-OLD ISOLATED, MODERATE, AND DENSE DRYOPTERIS LUDOVICIANA CULTURES.

Meristic males produced 100–300 antheridia after they became cordate. The antheridia occurred on two-thirds of the wings, and

extended to within four cells of the notch meristem. Meristic males continued to produce antheridia after being transplanted back to soil, and were not bisexual after 105 days.

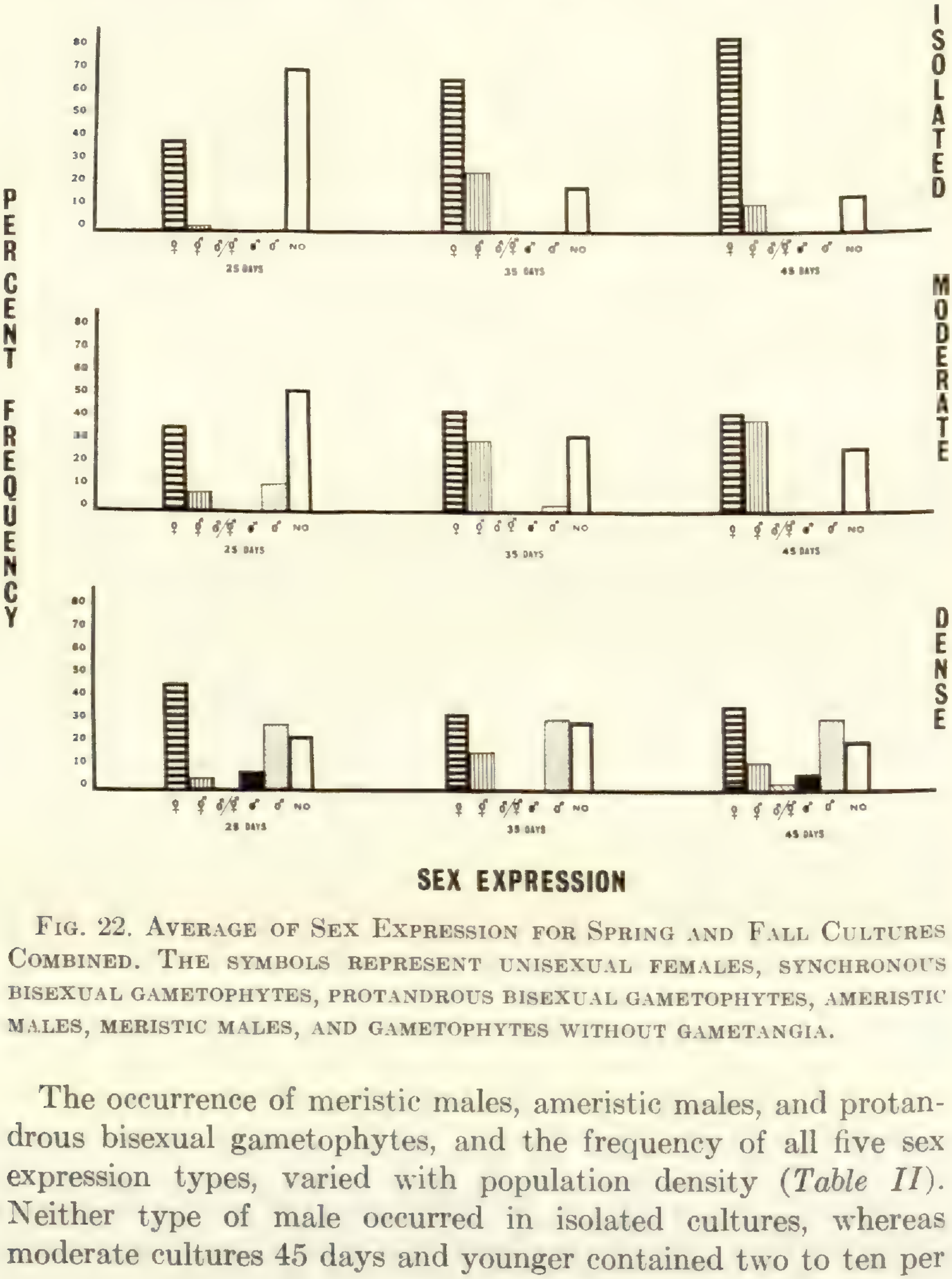


FIG. 22. AVERAGE OF SEX EXPRESSION FOR SPRING AND FALL CULTURES COMBINED. THE SYMBOLS REPRESENT UNISEXUAL FEMALES, SYNCHRONOUS BISEXUAL GAMETOPHYTES, PROTANDROUS BISEXUAL GAMETOPHYTES, AMERISTIC MALES, MERISTIC MALES, AND GAMETOPHYTES WITHOUT GAMETANGIA.

The occurrence of meristic males, ameristic males, and protandrous bisexual gametophytes, and the frequency of all five sex expression types, varied with population density (*Table II*). Neither type of male occurred in isolated cultures, whereas moderate cultures 45 days and younger contained two to ten per

cent meristic males. Dense cultures had both types of unisexual male gametophytes at a 28–33 percent level.

Unisexual female and synchronous bisexual gametophytes occurred in all 25-day-old cultures (*Table II*; *Fig. 22*). Most of the unisexual females bore receptive archegonia at this time; most gametangia on synchronous bisexual gametophytes were immature.

Sexuality was expressed rapidly in dense cultures, as only 10–23 per cent of the gametophytes in 25-day cultures were without sex organs. Forty-eight per cent of the gametophytes in 25-day moderate cultures were asexual, whereas isolated cultures were slowest, with 57–71 per cent remaining asexual at 25 days. The proportion of gametophytes without sex organs decreased with time in all cultures from an average of 19 per cent at 45 days (*Table II*; *Fig. 22*) to zero at 105 days.

Protandrous bisexual gametophytes were first found in dense cultures at 45 days and they remained at a two to four per cent level during 105 days of culture. The proportions of other sex expression classes in dense cultures remained approximately uniform through time, except for the absence of ameristic males at 35 days (*Table II*; *Fig. 22*).

The proportion of synchronous bisexual gametophytes increased with time in moderate cultures, but the proportion of unisexual females remained uniform. In 58 and 72–day-old moderate cultures protandrous bisexual gametophytes occurred at a 10–15 per cent level and meristic males increased to 31–40 per cent.

The proportion of unisexual females in isolated cultures increased from 35 per cent at 25 days to 77 per cent at 45 days, while the proportion of unisexual females in moderate and dense cultures varied little from the initial percentage.

The *Thelypteris dentata* gametophytes which were cultured under the same conditions as *Dryopteris ludoviciana* expressed the protandrous bisexual pattern in all observed cases.

DISCUSSION

The ontogeny of *Dryopteris ludoviciana* as described here does not differ significantly from the typical cordate pattern of the

Polypodiaceae *sensu lato*. The ontogeny of *D. ludoviciana* does not distinguish it from either *Aspidium spinulosum* Swartz [*Dryopteris spinulosa* (Muell.) Watt.] or *A. thelypteris* Swartz [*Thelypteris palustris* Schott] as reported by Waldemann (1928). Kny's (1895) illustrations of the development of *Dryopteris filix-mas* gametophytes fail to distinguish it from *D. spinulosa*, *D. ludoviciana*, and *Thelpyteris palustris*. It is likely that both *Dryopteris* and *Thelypteris* gametophytes have evolved to the same specialized level, and that gametophyte morphology is of little value in distinguishing between dryopterid and thelypterid ferns.

The five sex expression types found in *Dryopteris ludoviciana* populations allow intragametophytic mating and two levels of intergametophytic mating. Intragametophytic fertilization eliminates heterozygosity. Intergametophytic fertilization between gametophytes from the same sporophyte is equivalent to self-pollination and reduces heterozygosity. Intergametophytic fertilization between gametophytes derived from different sporophytes is equivalent to cross-pollination and increases heterozygosity (Klekowski, 1969).

The first sexual gametophytes observed in all populations were unisexual females, and the potential for intergametophytic fertilization was initially great. Intragametophytic fertilization became possible five to fifteen days later when synchronous bisexual gametophytes matured.

Although the pattern of spore distribution for naturally occurring *D. ludoviciana* plants is not known, it is likely that a greater number of spores will fall near the parent sporophyte and that spore density will decrease with distance from the parent plant.

Fertilization is most likely in dense populations because all five sex expression types occur and gametophytes often overlap. Fertilization is less likely in moderate populations and is least likely in isolation.

Dense populations from a single sporophyte have a high likelihood of intergametophytic gamete exchange which reduces heterozygosity, but are unlikely to effect exchange with gametophytes derived from different parent sporophytes. Synchronous bisexual

gametophytes would maintain a low level of intragametophytic fertilization in dense populations (*Table II; Fig. 22*). Moderate populations have the highest level of intragametophytic fertilization because of the high proportion of synchronous bisexual gametophytes. The potential for intergametophytic fertilization is lower than that of dense populations because fewer gametophytes overlap. Decreased population density would, however, increase the likelihood of establishment of a foreign spore. This would increase the possibility of intergametophytic fertilization at a level which increases heterozygosity.

Isolated bisexual gametophytes could establish sporophytes by selfing. Isolated unisexual female gametophytes would fail to establish a sporophyte, except where spore distribution patterns of different *D. ludoviciana* plants overlapped. The resulting sporophyte would greatly increase heterozygosity in the gene pool.

Variation of sex expression types found in different population densities implies the existence of a population factor which influences sex expression. The occurrence of unisexual males in dense and moderate cultures, but not in isolation, indicates that this factor influences maleness. Döpp (1950), who discovered an antheridium-inducing substance in *Pteridium aquilinum*, found that the *Pteridium* factor induced precocious antheridium formation in *Dryopteris filix-mas*, and an aqueous extract from *D. filix-mas* gametophytes induced antheridia on *P. aquilinum*.

Näf (1958, 1961) determined the mode of action of the *Pteridium* factor in *P. aquilinum* populations; his findings parallel certain aspects of the *Dryopteris ludoviciana* system. He found that unisexual females, ameristic males, and protandrous bisexual gametophytes occurred in *P. aquilinum* populations. Isolated gametophytes became unisexual females only, while all gametophytes became ameristic males if cultivated under conditions of slow growth with added *Pteridium* factor. Susceptibility to the induction of antheridia ceased before archegonia were formed, and the fastest growing gametophytes in the population probably attained the insensitive phase before the concentration of the factor was sufficient to induce antheridia.

The fastest growing *Dryopteris ludoviciana* gametophytes also become unisexual females, and maleness does increase with population density. The occurrence of bisexual gametophytes in isolation, however, cannot be the result of an antheridium-inducing substance secreted by other gametophytes. The antheridium-inducing factor also fails to explain the typical bisexual pattern of the majority of leptosporangiate ferns.

It is possible that the typical bisexual condition of most fern gametophytes is the ancestral condition, and that the *P. aquilinum* system is derived. In this latter case all spores are potential unisexual female gametophytes, and other sex expression types are determined by the interaction of an antheridium-inducing substance and variation in growth rate. If this is so, then the *D. ludoviciana* system is an intermediate one which shares the advantages of both the ancestral and advanced conditions.

At its present level of evolution the *D. ludoviciana* system has three favorable adaptations which increase its evolutionary potential. Sporophyte production is guaranteed in all population densities by a persistent level of the ancestral bisexual condition. Where a sporophyte population is already established, the level of heterozygosity is maintained by two levels of intergametophytic fertilization, so that the ability of the population to adapt to a changing environment is not lessened. The potential to increase heterozygosity is highest at the limit of the range so that range extension is possible by gamete exchange between neighboring *D. ludoviciana* populations. Finally, unlike *P. aquilinum*, some isolated spores can produce bisexual gametophytes which may self to form a sporophyte. This would allow range extension of the species throughout a habitat and disjunct range extension when scattered spores occur in a suitable habitat far removed from that of the parent sporophyte.

The role of the gametophyte in the natural distribution of ferns has not been assessed. Fern spores do act as long distance propagules, but the establishment of a gametophyte does not guarantee sporophyte occurrence (Farrar, 1967). Both gametophyte and sporophyte are subjected to selection in range exten-

sion of the species. Gametophyte adaptations, which would seem to encourage colonization, may be ineffective if the sporophyte is limiting. The relative effectiveness of gametophytes and sporophytes in colonization, the frequency of gametophyte establishment, and the occurrence of sex expression types must now be determined in the field.

LITERATURE CITED

ATKINSON, L. R., and A. G. STOKEY. 1964. Comparative morphology of the gametophyte of homosporous ferns. Phytomorphology **14**: 51–70.

BROWN, C. A., and D. S. CORRELL. 1942. Ferns and Fern Allies of Louisiana. Louisiana State Univ. Press, Baton Rouge, Louisiana.

DÖPP, W. 1950. Eine die Antheridienbildung bei Farnen förderne Substanz in den Prothallien von Pteridium aquilinum (L.) Kuhn. Ber. Deut. Bot. Ges. **63**: 139–147.

FARRAR, D. R. 1967. Gametophytes of four tropical fern genera reproducing independently of their sporophytes in the Southern Appalachians. Science **155**: 1266–1267.

KLEKOWSKI, E J., JR. 1969. Reproductive biology of the Pteridophyta. II. Theoretical considerations J. Linn. Soc. London (Bot.) **62**: 347–359.

————, and H. G. BAKER. 1966. Evolutionary significance of polyploidy in the Pteridophyta. Science **153**: 305–307.

————, and R. M. LLOYD. 1968. Reproductive biology of the Pteridophyta 1. General considerations and a study of Onoclea sensibilis L. J. Linn. Soc. London (Bot.) **60**: 315–324.

KNY, L. 1895. Entwicklung von Aspidium filix-mas. Bot. Wandtafeln **9**: 411–438.

NÄF, U. 1958. On the physiology of antheridium formation in the bracken fern (Pteridium aquilinum (L.) Kuhn). Physiol. Plant. **11**: 728–746

————. 1961. On the physiology of antheridium formation in ferns, pp. 709–723. *In* R. M. Klein, *ed*. Plant Growth Regulation. Iowa State Univ. Press, Ames, Iowa.

NAYAR, B. K., and P. CHANDRA. 1963. Observations on the morphology of the gametophyte of Cyclosorus. J. Indian Bot. Soc., B, **42**: 392–400.

WALDEMANN, H. 1928. Beiträge zur Entwicklungsgeschichte der Prothallien einheimischer Polypodiaceen. Dissertation, Univ. Marburg, Germany.

WILKIE, D. 1956. Incompatibility in bracken. Heredity **10**: 247–256.

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Shorter Notes

A NEW FORM OF MICROLEPIA SPELUNCAE.—A cultivated form of *Microlepia* that is a very graceful and delightful plant for greenhouses (and possibly outdoors in southern California) has been introduced rather recently. It was in cultivation in the Botanical Garden of Ajuda, Lisbon, Portugal, and material was brought back by Dr. F. G. Meyer to the Department of Agriculture, where it is in cultivation in Glenn Dale, Maryland (Plant Introduction no. 241,924). In Portugal it was passing as *Microlepia strigosa* (Thunb.) K. B. Presl cv. *'Cristata'*; however, the plant is quite different from *M. strigosa*, which is a related species also in cultivation. In habit it is quite like the plumed form of the English Lady Fern, *Athyrium filix-femina* cv. *'Corymbiferum'* (cf. Druery, "British Ferns and Their Varieties," *pl. 9*). The new plant is a beautifully crested form of *M. speluncae* (L.) Moore, which has also long been in cultivation. *Microlepia strigosa* and *M. speluncae* can be distinguished by these characters:

Veins (at least in dried material) prominently raised on the lower surface; hairs of rhachises and midribs coarse, mostly upwardly directed toward the apex of the pinnae; blades bipinnate or bipinnate-pinnatifid. . *M. strigosa*

Veins (at least in dried material) not raised above the surface beneath; hairs of rhachises and midribs fine, horizontally spreading; blades tripinnate to quadripinnate..... *M. speluncae*

MICROLEPIA SPELUNCAE CV. **'Corymbifera'** Morton, CV. NOV.

Main rachis 4- or 5-times forked, forming a plumelike tip; lateral pinnae mostly drooping, forked and plumose at the tips.

TYPE: Botanical Garden of Ajuda, Lisbon, Portugal, August 10, 1957, *F. G. Meyer 5096* (US 2,292,318).

This plant is also in cultivation at Longwood Gardens, Kennett Square, Pennsylvania (Acc. no. 58,498), grown from material received from Meyer, *Wikoff 1200* (US 2,292,212-3), *Huttleston 2246*. Although the plant I have described is a recent introduction, the same thing may already be in cultivation in the United States, for I recall seeing similar forms in some greenhouses.—C. V. MORTON, *U. S. National Museum, Washington, D. C. 20560.*

Holotype of Microlepia speluncae cv. 'Corymbifera'

TWO NEW STATE RECORDS FOR ISOËTES IN KENTUCKY.—The genus *Isoëtes* has not been known positively for the state of Kentucky. Davies (Ann. Kentucky Nat. Hist. **1:** 33–44. 1949) reported *Isoëtes engelmannii* A. Braun in Jefferson County, but searches in the area in later years failed to confirm its existence there, according to Reed (Castanea **26:** 94–96. 1961).

A recent floristic survey of Edmonson and Warren Counties has revealed the presence of two species of this genus. *Isoëtes engelmannii* has been collected from three different localities in Edmonson County, and *I. melanopoda* Gay & Durieu has been collected from wet prairies and temporary pools in Warren County south of Bowling Green.

Dr. Warren H. Wagner, Jr. has kindly examined the Warren County specimens and has stated that they definitely belong to the *I. melanopoda* group. Voucher specimens have been deposited in the herbarium of Western Kentucky University.

It is anticipated that as more extensive field investigations are made, this genus will prove to be much more widely distributed in Kentucky than past and present records indicate.—HAROLD W. ELMORE, *Department of General Biology, Vanderbilt University, Nashville, Tenn. 37203.*

PSILOTUM NUDUM NEW TO ARIZONA.—In a collection of plants received for identification at the University of Arizona was a specimen of *Psilotum nudum* (L.) Palisot, a new record of the genus for Arizona. The specimen was collected by Mr. Jack Kaiser, of the Plant Quarantine Service, U. S. Department of Agriculture, in Sycamore Canyon, Santa Cruz County, Arizona (*Fig. 1*). This canyon has been much studied by Mr. Leslie Goodding, who, however, never found this species. The plant grows in rock crevices (*Fig. 2*) and is definitely not plentiful. I have made several collecting trips to search for it, and I did find the one location where it grows. However, since it is so rare, I collected only just a small sprig or two for the University of Arizona Herbarium. The canyon is steep and hard to negotiate, but a careful search has not turned up any additional plants. Sycamore Canyon

Fig. 1. Sycamore Canyon west of Nogales, Arizona. Fig. 2. Psilotum nudum growing in a rock crevice in Sycamore Canyon.

is located about 20 miles west of Nogales. The location for the *Psilotum* is about a six mile hike down the canyon.

Psilotum nudum is widespread in the tropics and occurs also in Florida and the southeastern United States. It has been recorded also from Texas by Correll, and from the Río Mayo, Sonora, Mexico, by Gentry. The latter is the closest recorded locality. Incidentally, the Ball Moss, *Tillandsia recurvata* L., the only epiphytic flowering plant known in Arizona, also grows in Sycamore Canyon and a few other southeastern Arizona localities. It has a range similar to that of *Psilotum*—Florida and the southeastern United States, Texas, and northern Mexico.—WALTER S. PHILLIPS, *Department of Biological Sciences, University of Arizona, Tucson, Arizona 85721.*

Notes and News

THE AMERICAN FERN SOCIETY ANNUAL MEETING this year will be with the A.I.B.S. at Bloomington, Indiana, on the campus of Indiana University. Dr. Charles Heiser will be our local representative. We will have a foray on August 20–22. Foray reservation requests should be sent to Miss Lois Carlson, Matthaei Botanical Garden, University of Michigan, Ann Arbor, Mich. 48105. On August 24 we will have a Society luncheon, along with a program of papers. Dr. John T. Mickel, New York Botanical Garden, Bronx Park, Bronx, N. Y. 10458 is the program chairman. On August 25 the Society will sponsor a symposium on "Ferns as Tools in Solving Biological Problems." The General Section and the Developmental Section of the Botanical Society of America will co-sponsor the symposium.

Recent Fern Literature

THE ILLUSTRATED FLORA OF ILLINOIS: FERNS, by Robert H. Mohlenbrock, Southern Illinois University Press, Carbondale, Illinois, 1967. 119 pp. $8.00.—This, the most recent state fern flora, is similar in format to Billington's "Ferns of Michigan," but

it does include some new data regarding spores and chromosome numbers not treated by Billington. It differs from Vannorsdall's "Ferns of Ohio" in that it is illustrated by drawings rather than photographs, which is not always an advantage. Mohlenbrock's drawings of details are good, as are some of those of small ferns, but the larger compound ferns like *Dryopteris carthusiana* (*D. spinulosa*), *D. intermedia*, and others are not recognizable from these drawings but are readily recognizable from Vannorsdall's photographs. The last enumeration of Illinois pteridophytes recorded 67 species; the present work treats 81 species and six varieties. This large increase is partly due to intensive fieldwork during the last few years and partly due to different specific concepts. The 81 species include a number of hybrids perhaps not qualifying as true species. The treatment of each species includes the common names, habitat, general range, Illinois range with map, and taxonomic comments. One new variety is described, *Lycopodium lucidulum* var. *tryonii*, which differs in having the leaves entire, and which is said to be known only from Jackson County, Illinois. It seems rather unlikely that a true variety of the widespread *L. lucidulum* would be known from a single locality. The plant described could well be a hybrid with *L. porophilum*, which apparently has not been collected in Jackson County, but which does grow not far away. I believe that I have heard of reports of such entire-leaved plants from outside Illinois also. There are a few errors that might be pointed out. The drawing of *Adiantum pedatum* is inaccurate in not showing the solitary pinnules that are present on the internodes beyond the second fork; these isolated pinnules are important for they may help to explain the branching, if they are equivalent to all the rest of a branch. *Dryopteris cristata* is said to have a chromosome number of $2n = 246$, but I believe that this is an error, for this is regarded as a tetraploid ($2n = 164$) rather than a hexaploid. The description of the indusium of *Dennstaedtia* as "modified from a recurved tooth of the leaf margin" is not accurate, for the indusium is partly an extrorse inner indusium united with a modified introrse marginal lobe. The entry in the key on page 85 separating *Woodsia* from

Cystopteris will hardly work, for the indusia in *Woodsia* are said to separate into "shreds," which would apply to *W. ilvensis* but hardly to *W. obtusa*, where the indusial lobes are broad. However, these are strictly minor criticisms. The book is creditable and usable and should be in the libraries of fern students.—C.V.M.

VASCULAR PLANTS OF THE PACIFIC NORTHWEST, PART 1. By C. L. Hitchcock, A. Cronquist, M. Ownbey, and J. W. Thompson. 914 pp. 1969. University of Washington Press, Seattle, Washington 98105. $25.00.—This, the fifth and last volume of the flora of the Pacific Northwest, completes this monumental work, the first parts of which were published several years ago. Although the last to be issued, this is the first part, which contains the treatment of the vascular cryptogams, the gymnosperms, and the monocotyledons, including the large and difficult groups Cyperaceae and Gramineae. The present part contains a glossary, a general index, and an appended list of additions and corrections to the previously published parts. The ferns and fern allies are treated by Dr. Cronquist, and very well too. The keys are accurate and usable—not too technical but technical enough when necessary. One detail is that finite verbs are sometimes used in the keys—e.g. p. 57, ". . . indusium which is so close to the margin . . ." or "submarginal row that is protected by . . ."; the use of such "which" clauses is not usual in botanical keys and is never necessary. The treatment is conservative in its recognition of varieties, species, and families. I approve of placing the true ferns all in the inclusive family Polypodiaceae at least until much more is known about their morphology, cytology, and evolution. Cronquist does indicate in the key some of the groups that have been called families, including one called "Aspidiaceae." This is an incorrect name because according to the Code of Nomenclature a family name must be based on the name of a legitimate genus, and *Aspidium* is an illegitimate generic name, superfluous when published because it originally contained the type species of several earlier generic names that ought to have been adoped, such as *Dryopteris*, *Thelypteris*, *Tectaria*, *Athyrium*, *Polystichum*, and perhaps others.

The proper family for this group depends on how finely it is split up itself into families; in the rather inclusive sense used by Cronquist, the proper name is probably Aspleniaceae, but if *Asplenium* is placed in a different family, the remainder should probably be called Dryopteridaceae. The names of the classes accepted by Cronquist are Lycopodiatae, Isoëtatae, Equisetatae, and Polypodiatae, according to a suggestion that Cronquist, Jeffrey, and Takhtajan made to the recent International Botanical Congress. However, the Congress rejected this change, and so these names should not be accepted, since the Code says that the termination for classes should be "–opsida." The "Polypodiatae" should probably be called the Filicopsida. *Selaginella* is included in the Isoëtatae, presumably chiefly because of its heterospory, but I can't really believe that *Selaginella* is more closely allied in a phylogenetic way to *Isoëtes* than to *Lycopodium*, with which it seems obviously to have much more in common. Cronquist includes the heterosporous *Azolla* and *Marsilea* in the Polypodiatae, and so there is no a priori reason why heterospory could not have developed also within the Lycopodiatae. Types are cited, as they should be in a flora when space permits, but they are done here in a very unusual way. Normally a type is cited either after the accepted name or after the name-bringing basionym, and so it is here sometimes. But not always. For instance, in *Polypodium hesperium* Maxon (1900), the type is not cited after this original and accepted name but following the later synonym *P. vulgare* var. *hesperium* Nels. & Macbr. (1916); there does not seem to be any justification for this.

There are a number of details that ought to be commented on. The author of the combination *Cystopteris montana* (Lam.) is left undecided; the authority "Bernh." used by Blasdell in his revision and by others is wrong; however, there seems to be no reason not to accept Desv. Mém. Soc. Linn. Paris **6:** 264. 1827, as used in the "Flora Europaea," until someone can come up with an earlier usage, which is probably not possible. The authority for *Blechnum spicant* is given as Withering (1796), but it was shown long ago by Mansfeld (Repert. Sp. Nov. **45:** 202. 1938) that the

combination had been made two years previously by Roth (in Usteri, Neue Annalen 2(10): 46. 1794) (cf. Maxon, Amer. Fern J. **34:** 51. 1944). The authority for *Woodwardia fimbriata* has been accidentally omitted; it is J. E. Smith in Rees; incidentally, I saw and photographed the holotype in the J. E. Smith Herbarium in the Linnean Society last spring. It is the stated intention to include all synonyms based on material from the Pacific Northwest, but one has been omitted here—*Blechnum doodioides* Hook. Fl. Bor. Amer. **2:** 263. 1840. The type locality of this species is not definitely known, but it was collected by Douglas and surely in the Pacific Northwest; Hooker thought that it might have come from Hudson Bay, but that is obviously impossible since this species does not grow there or anywhere nearby. This synonym is of some importance, for it would be the earliest specific epithet for the plant of this area if it should ever be separated from the European type, which is not at all inconceivable. The type was a somewhat abnormal specimen with the sori somewhat interrupted.

Another synonym that has been omitted, although the type is from the area concerned, is *Woodwardia paradoxa* C. H. Wright (Gard. Chron. **41:** 98. 1907), a synonym of *W. fimbriata*. The type was collected on a small, undesignated island off the coast of Vancouver Island, B. C., by F. W. Moore, and will presumably be in the herbarium at Kew. Strangely enough, Wright did not compare his species with *W. fimbriata* or its synonym *W. chamissoi*, but with the European *W. radicans*, apparently unaware that the Pacific Coast plant had ever been separated as a species.

Cheilanthes lanosa Michx. is reported for the northwest for the first time in this publication. The plant is supposed to have been collected at high elevations on Mount Jupiter in the Olympic Mountains of Washington. I have been aware of it for several years, but I have had some doubts about it. This is an eastern species and the nearest known natural occurrences are in Minnesota, more than 1,000 miles to the east. The plant on Mount Jupiter was brought down and cultivated in a garden in Brinnon, Washington, and it is possible that here it became confused with a cultivated plant of the eastern *C. lanosa*. Later attempts to

find this species again on Mount Jupiter have been unsuccessful. Following the "Flora Europaea" and some recent authors, Cronquist has adopted *Isoëtes setacea* Lam. for the common spiny-spored plant of the northern United States and Canada. This has very recently been shown to be wrong; the comment by C. Jermy (Brit. Fern Gaz. **10:** 106. 1969) deserves to be quoted in full: "*Isoëtes setacea* Lam. for *L. echinospora* Dur. is an unfortunate change for which I am partly responsible. When I wrote the account of *Isoëtes* for "Flora Europaea," I was aware that Rothmaler and later Fuchs had identified the type specimen of *I. setacea* Lam. as *I. echinospora*. I had seen only a photograph and been told that the plants were immature, and I had agreed that, superficially, this specimen did indeed have the habit of *I. echinospora*. However, I have since had occasion to study this specimen in the Paris Museum and through the kindness of Mme. Tardieu-Blot I was able to remove a few immature megaspores and study them under the scanning electron microscope. Only now, after seeing some hundreds of megaspores from a wide range of species and at various stages of maturity, do I feel confident in placing the Lamarck specimen in the section *Tuberculatae* and not *Echinatae*. In other words we must revert to the *status quo* and I must apologize to Mr. Harrison and others who have taken up the name *I. setacea* Lam., the identity of which is now being investigated." This illustrates the coming importance of the scanning microscope for spore studies. The proper name for the Pacific Coast plant called *I. setacea* by Cronquist is probably *I. echinospora* Dur. Recently, Fuchs (Nova Hedw. Beih. **3:** 51–78. 1962) has taken up the earlier name *I. tenella* Desv. (Mém. Soc. Linn. Paris **6:** 179. 1827), but the identity of Desvaux' type (Fl. Danica *t. 191*) with *I. echinospora* has been challenged. As a variety the name is *I. echinospora var. braunii* and as a distinct species *I. muricata* Dur. The species *Dryopteris austriaca* Jacq. is accepted in the inclusive sense that I myself adopted in my treatment of the eastern ferns in Gleason's "New Illustrated Flora" (1952). I still think that this is a possible treatment of the group, but recent cytological studies have indicated that it might be better to recognize several species.

If so, the position in the Pacific Northwest is far from clear. Most of the plants would fall into what has been called a diploid *Dryopteris dilatata*. But the true *dilatata* from Europe (*D. austriaca* Jacq. var. *austriaca*) is a tetraploid, and it has been suggested that our Pacific coast *dilatata* is really the diploid species *D. assimilis* S. Walker (in Clapham, Tutin, & Warburg, Brit. Fl. ed. 2. 1962) of the British Isles; this has been indicated not only by the chromosome number but also by chromatography. The true tetraploid *D. spinulosa* does apparently also reach into the Pacific Northwest, for I have seen a specimen that seems to be surely this rather than *D. assimilis* (Orogrande Creek, Clearwater County, Idaho, *Epling & Houck 9349*). The proper name for "*D. spinulosa*" (an illegitimate name) is still uncertain; the name *D. carthusiana* (Vill.) H. P. Fuchs has been accepted recently, but Jermy indicates that there is grave doubt that Villar's type is really this species; this kind of doubt is to be expected in a group like this that is cytologically complex and little understood even after intensive study for many years.—C. V. M.

A REVISED FLORA OF MALAYA, VOL. II—FERNS OF MALAYA, ED. 2, by R. E. Holttum. Gov't. Printing Office, Upper Serangoon Road, Sinagpore, 13. 1966. 653 pp. ca. $7.50+postage.—The original edition of this popular and useful book appeared in 1954 (see this JOURNAL **46**: 158. 1956). Despite one reprinting, it has been out of print for several years. The new edition is largely identical to the first. A few pages, however, are totally redone and Appendix II, a ten-page list of changes and corrections to the first edition, is added. In recent years several studies bearing on the Malayan fern flora have been published, principally by Prof. Holttum and Mrs. B. E. G. Molesworth Allen. Besides incidental changes in many genera, considerable emendations have been made in *Cyathea*, *Dicranopteris*, *Gleichenia*, *Lygodium*, and *Ophioglossum*, and *Diplazium* has been separated from *Athyrium*. Entries in the main text that are amplified or corrected in Appendix II have been marked with an asterisk. Names in Appendix II unfortunately have not been included in the index. For readers who have the

first edition, Appendix II alone may be purchased from the publisher for about $0.75.—D.B.L.

CHROMOSOMES AND SPECIATION IN FERNS, by Kunio Mitui. Sci. Rep. Tokyo Educ. Univ. [Tokyo Kyoiku Daigaku], **B, 13**:285–333. 1968.—This is the first comprehensive listing of chromosome numbers of the Japanese ferns, treating 66 genera and 202 species. The mean sizes of the chromosomes of some of the species are stated; these vary from 3 μ to 7.5 μ. A number of presumed triploids, autotetraploids, and allotetraploids were authenticated cytologically, some of which are distinguishable morphologically by spore size, stomatal size, texture, and habitat. Most homosporous ferns have relatively large chromosome numbers compared with phanerogams; Mitui believes that most modern diploid species are in reality old polyploids derived from ancient and extinct species with lower numbers. He considers that a similar chromosome size often indicates relationships among the genera, that the older genera have higher base numbers, that advanced genera have many polyploid or apogamous species, and that primitive genera like *Dennstaedtia* have many aneuploid species.—C. V. M.

BIBLIOGRAPHY TO FLORAS OF SOUTHEAST ASIA, by Clyde F. Reed. Published by the author, 10105 Harford Road, Baltimore, Md. 21234. 1969. 191 pp. $3.50.—Merrill and Walker's useful "A Bibliography of Eastern Asiatic Botany (1938, Supplement, 1960) covered the essentially temperate parts of eastern Asia from China and Taiwan northward, but not tropical southeastern Asia. This new index covers Burma, Laos, Thailand, Cambodia, Viet Nam, Malaya, and Singapore. The title is a little misleading because the work includes not only floras, which are rather few, but chiefly smaller taxonomic papers and also papers on fossil, cultivated, agricultural, and medicinal plants, forest timbers, and taxonomically oriented ecological papers. The bibliography would be more useful if it contained a subject index.—C. V. M.

American Fern Society

Report of the President for 1969

It is now time to give an accounting of our stewardship for the past year, but first I wish to extend my greetings to all of our members, both old and new. To the new members we say—become involved in the society and take advantage of the various services available to you. Let us know your needs.

In this report I shall only touch briefly on some aspects of the Society because other council and committee members will have more details to add.

As you all know, the big event of the year was the fern field trip conducted prior to the regular meetings of the XI International Botanical Congress held in Seattle, Washington. This was a wonderful experience for those of us who had not previously botanized in the Pacific Northewst. It was a tremendous thrill for me to see *Cheilanthes gracillima* and *Aspidotis densa* (formerly *Cheilanthes siliquosa*) growing in all their glory, since these are part of the group in which I am involved in my research.

We want to thank Neill Hall not only for his faithful custodianship of the Fern Spore Exchange but also for arranging a wonderful luncheon for the American Fern Society. He did a magnificent job. Over 80 people attended, including some members from here and abroad whom we had not seen in some years.

Our next meeting will be in conjunction with the American Institute of Biological Sciences next fall in Indiana. We plan a field trip, a luncheon, a paper session, and a symposium on "Ferns as Tools in Solving Biological Problems." Your Council decided to meet again with the AIBS in 1971 in Colorado, rather than with the Botanical Society of America in Edmonton, Canada, for the fern flora is richer in Colorado than it is in that part of Canada.

Parts of the booklet on ferns have been written and we expect further progress this coming year. The Journal Index and membership list are also being worked on by committees set up by your President. May I again issue a plea to all of our members to

remember the Society financially in whatever way seems appropriate. We will need more money than we can now spare for the above publications. In addition, we would all like to see a larger number of pages in the Journal, and this costs money. Mrs. Una Weatherby, Miss Scamman, Dr. Wherry, and others have made gifts or bequests in the past, and we hope their example will be followed.

When one attempts to assess the health of the American Fern Society by checking membership figures, one finds an up-and-down pattern during the past ten years. We now have about 600 domestic and foreign members plus over 300 institutional subscribers to the Journal. In recent years the low was 633 members in 1968 and the high was 896 in 1962. When I consider the general increase in population in the United States, and when I view the above figures, I can only say that I am not too pleased with our membership growth. Your Council grapples with this problem every year. Do you have a suggestion for increasing membership? Would each of you try to get one new member this year? If you are organization-minded and live in a fern-rich area, why not contact Society members and friends and plan a local field trip? We certainly encourage you to do these things, for in this way, you can increase the health of the Society.

Respectfully submitted, IRVING W. KNOBLOCH, *President*

Report of the Secretary for 1969

Individual membership in the American Fern Society at the end of 1969 stands at 603 members, with an additional 327 institutional subscribers to the Journal. Members and subscribers come from every state in the union and 45 foreign countries. However, these figures represent a rather abrupt loss of about 60 individual members over the last two years and down from an all time high of 896 in 1962. This may be a time to push membership or to re-evaluate our role and function as a society.

I report with regret the death of four members: Mr. J. E. Benedict, Jr., a member since 1923; Dr. Bayard Long, a member since 1911; Mrs. W. E. McArthur, a member since 1964; and Mr. David H. Perry, a life member since 1953.

The annual meeting of the Society was held in conjunction with the XI International Botanical Congress, August 24–September 2, 1969, at The University of Washington in Seattle. The Society joined with the Congress in sponsoring a Pre-Congress Pteridology field trip from August 18 to August 22 in the Cascade Mountains of Washington. This trip will be reported in detail at a later date. Because of the decision of the Congress that there would be no sessions devoted to any special plant groups, there was no formal session at which members of the society presented research papers. Rather, research papers concerning ferns were scattered throughout the program of the Congress; it is impossible to list them here. The formal meeting of the Society was a luncheon meeting on Tuesday, August 26, attended by about 80 persons and presided over by President Irving Knobloch. Several foreign members attending the meeting were Dr. H. P. Fuchs from the Netherlands, Dr. R. E. Holttum from England, E. A. Turnau from Malaya, and several from Canada, including Dr. T. M. C. Taylor and Mrs. E. Kenzie.

The Council met following the luncheon, with all members present. Approval was given to reprint copies of 20 back issues of the American Fern Journal to fill out our stock and to move our funds from the Greenpoint Savings Bank to an appropriate bank in Pittsburgh which would afford the Society a greater interest rate. Discussion also concerned progress on a booklet on ferns for the general public. It is hoped that this booklet will soon become a reality, as it would be a great help to the Secretary in responding to numerous requests for general information on ferns.

Respectfully submitted, A. MURRAY EVANS, *Secretary*

Report of the Treasurer for 1969

Although receipts from all sources for the year 1969 were $7,136.83, which is much lower than last year, we still ended the year with $2,617.68 in the checking account. We invested the Scamman bequest of $3,000 in a savings account, where it will draw 5 per cent interest compounded quarterly. Our four savings

accounts earned $439.11 in 1969. Royalties from Dr. Wherry's books increased by $85.22, and sale of reprints by $46.12.

We paid $2,868 for the reprinting of 200 copies of 21 back issues of the JOURNAL from the checking account.

Advance payment for dues increased by $69.11, and for subscribers by $311.21.

We obtained 23 new subscribers and lost 16 through cancellation or resignation, making a gain of 7.

Taking into consideration the above statements, I believe that the American Fern Society is in good financial condition.

Receipts

Cash on Hand, January, 1969		$ 6,902.15
Membership Dues		
Renewals	2,159.68	
Sustaining	180.00	
New	267.00	
Advance	189.11	
Arrears	33.20	
		2,828.99
Subscriptions		
Current	486.61	
Advances—1970	903.00	
Advances—beyond 1970	85.00	
Arrears	28.10	
		1,502.71
Sale of Back Issues of Journal		1,608.92
Sale of reprints		523.34
Royalties (Wherry's books)		579.25
Gifts	4.86	
Page and Plate charges	105.00	
Advertising in Journal	14.30	
Spore Exchange for 1968	30.21	
Miscellaneous	17.30	
		7,214.88
Total Receipts		
Total		$14,117.03

Disbursements

American Fern Journal		
Vol. 58, No. 4		1,032.20
Vol. 59, No. 1		960.35
Vol. 59, No. 2		1,058.93
Vol. 59, No. 3		1,198.96
		4,250.44
Reprints and postage		445.37
Envelopes for mailing Journal		97.00
Printing stationery, envelopes, billheads, etc.		100.25
Treasurer's expenses (stamps and supplies)		111.14
Secretary's expenses		96.83
Editor's expenses		7.32
Ad of Society in L. A. Fern Publ.		10.00
Treasurer's bond renewal for 3 years		31.00
Deposited in Green Point Sav. Bank (Life Mem. Fund)		80.00
Opened a Savings Account at Union Nat. Bank (Scamman Fund)		3,000.00
Refunded to Agencies		10.00
AIBS dues		400.00
Reprinting of back issues of Journal	2,860.00	
Total		11,499.35
Cash on hand, January 1, 1970		$ 2,617.68

Statement, December 31, 1969

Assets

Cash in Union National Bank	$ 2,617.68
Cash in Green Point Savings Bank	
Bissell Herbarium Fund	1,079.73
Life Membership Fund	1,773.05
Weatherby Fund	4,563.65
Cash in Union Nat. Bank	
Scamman Fund	3,080.70
Accounts Receivable	
(Two sets of Journals and 6 reprint bills)	600.54
Inventory, Journal (23,178 @ .50)	11,589.00
Library	396.00
Total	$25,700.35

Liabilities

Advance dues	189.11
Advance Subscriptions	1,126.61
Fund balances	
Bissell Herbarium Fund	1,079.73
Life Membership Fund	1,773.05
Una Weatherby Fund	4,563.65
Scamman Fund	3,080.70
General Fund	13,887.50
Total	$25,700.35

Respectfully submitted,

LEROY K. HENRY, *Treasurer*

Report of the Auditing Committee

We hereby certify that we have seen the books and accounts of Dr. LeRoy K. Henry, Treasurer of the American Fern Society, Inc., and have obtained confirmation of the correctness of the Society's balance on hand as set forth in detail in the accompanying report of the Treasurer.

Dorothy L. Pearth, *Auditor*

Report of the Judge of Elections

The essential results of balloting for officers of the American Fern Society are as follows:

For President:
Warren H. Wagner, Jr. 280

For Vice-President:
John T. Mickel 278

For Treasurer:
LeRoy K. Henry 276

I therefore declare the following candidates elected to office: Warren H. Wagner, Jr., President; John T. Mickel, Vice-President; LeRoy K. Henry, Treasurer.

Respectfully submitted, ALAN R. SMITH, *Judge of Elections*

Report of the Fern Spore Exchange

The Fern Spore Exchange has made consistent growth in all respects. Twenty three universities or botanical gardens of other countries are participating in the Exchange, along with 65 in the United States. The fern societies of England and Japan both contribute to the Exchange, as well as many individuals throughout the world.

A supplemental list to the 1967 and 1968 list has been distributed. These two lists include 489 species and varieties of ferns. Many of the items in the 1967–1968 list have been replaced with fresh spores, so selections should be made from items numbered from 450 to 939.

The packets of spores distributed in 1969 were almost double the number sent out in 1968, but the packets received were about the same as in 1968. The Berlin Botanic Garden and the University of California at Berkeley contributed a total of over 130 rare, choice species.

I wish to thank all the faithful members who have consistently contributed fresh spores to the Exchange. Special thanks are due Mr. C. V. Morton for checking the lists and Dr. Ira L. Wiggins who arranged for duplicating the lists over the past several years.

Please collect and send in fresh spores or fertile fronds. The Exchange must provide *fresh* spores at all times. Some items on the original list were collected in 1967 and some are out of stock. Therefore, the exchange is grateful for spores of *all* species.

Respectfully submitted, NEILL D. HALL, *Director*

New Members

M. Acedo-Diaz, Ricarda-Huch Strasse 6, 5 Koeln-80, Germany
Mrs. Virginia Ault, 1030 Oriole Ave., Miami Springs, FL 33166
Mr. John J. Barnes, 26 Bertmore Dr., Stamford, CT 06905
Mrs. Samuel M. Beattie, 30 Woodland Way, Greenville, SC 29601
Mr. Eugene A. Bond, West Road, Dorset, VT 05251
Mrs. P. N. Booker, Jr., 103 Pine Tree Dr., Gulf Breeze, FL 32561
Mr. Woodward S. Bousquet, 44 Waverly St., Pittsfield, MA 01201
Mrs. Laurel A. Cawrse, 21793 Mastic Rd., Fairview Park, OH 44126
Mr. James R. Falender, 11-5 Edgehill Terr., Troy, NY 12180

Mr. Scott Fikes, 3220 Botanic Garden Dr., Ft. Worth, TX 86107
Mrs. Philip D. Fletcher, Unicoi, TN 37692
Mrs. Richard O. Grisdale, 33 W. Beechcroft Rd., Short Hills, NJ 07078
Mr. Goeffrey R. Halliwell, No. 9 The Avenue, Bellambi, 2518, N.S.W., Australia
Mr. William Harper, Lena High School, Lena, WI 54139
Mr. J. M. Jacobsen, 880 E. Snell Rd., Rochester, MN 48063
Mr. Leopold W. Kaus, 1634 E. 96th St., Brooklyn, NY 12336
Mr. Jack Langrell, 9257 29th St. W., Seattle, WA 98126
Mrs. Madeline Lovett, 6016 Westchester Dr., College Park, MD 20740
Mrs. Harry D. Lubrecht, 4672 Broadway, New York, NY 10040
Mr. Robert Magill, 208 Sul Ross Village Apt., Alpine, TX 78930
Mr. Joseph F. Major, 47 Highland Ave., Somerville, NJ 08876
Mr. Monte Manuel, 9610 Lawndale Ave., Tacoma, WA 98498
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Published by the

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DAVID B. LELLINGER

C. V. MORTON ROLLA M. TRYON

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American Fern Journal

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American Fern Journal

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The Fern Collections in Some European Herbaria, VI

C. V. Morton

Hamburg

The herbarium and botanical garden of the Staatsinstitut für Allgemeine Botanik in Hamburg are not well known or often visited by taxonomists, in spite of the herbarium being one of the larger of the world herbaria and one of great importance for certain areas. There were private gardens in Hamburg from early times. The Hamburg Academic Gymnasium was founded in 1613, and many of its early professors were interested in botany, especially Joachim Jungius (1587–1657), who was appointed rector in 1629. Sachs, in his history of botany, states that Jungius was the first in Germany, as Caesalpinus was in Italy, to combine philosophical thoughts on botany with the true observation of living plants. It seems clear that Linnaeus studied the works of Jungius in his youth. Linnaeus visited Hamburg in his travels and commented on the richness of the gardens there, which included even then 50 species of the South African genus *Mesembryanthemum* and 45 species of *Aloe*.

The credit for the first large private garden must go to J. N. Buek, who was referred to as "the German Philip Miller," in reference to the noted English gardener of the same period. Buek's catalogue of 1779 had 200 pages of plants for sale.

Johannes Fluegge (1775–1816) was a talented Hamburg botanist. He got his doctorate in Erlangen in 1800 under Schreber, but even prior to this he had made many collecting trips in Germany with

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his friend Floercke (himself later professor of botany in Rostock and a noted bryologist of his time). He took the opportunity of making friends with all the botanists of his day—Martius, von Moll, Jacquin, Schrader, Hedwig, Schkuhr. Later he travelled in France and Italy, collecting, studying, and making the acquaintance of Richard, Gouan, Gilibert, Jussieu, Desfontaines, Allioni, Bellardi, and others. He thought to work on a flora of France, but abandoned the idea when he found DeCandolle engaged on the same project. During these years he exchanged thousands of plants with botanists in Germany, France, and England.

Fluegge returned to Hamburg in 1810 and decided to start a true public botanical garden. He sold about a hundred shares at 400 Marks Banco (600 RM) and was able to buy Buek's establishment, which at the time included about 1200 species. Willdenow sent plants from Berlin, Sprengel from Halle, Hornemann from Copenhagen, Thouin from Paris, Fischer from Gorenki, Balbis from Turin, and Bernhardi from Erfurt, and soon there were 3000 species in the garden, including many rare plants from Africa and Australia. Unfortunately, the army of Napoleon passed through Hamburg in 1813, leveling much of the city, including Fluegge's garden, which was completely destroyed, including the herbarium and manuscripts. Fluegge never recovered from this shock and died shortly thereafter of a "nervous fever." He is remembered today only from his "Graminum Monographiae", only one part of which was published (mostly on *Paspalum*), and the duplicate plants that he exchanged.

Hamburg citizens, having had a botanical garden for a few years, were not content without one, and so another was author ized. Johann Georg Christian Lehmann had been appointed Professor of Botany in 1818, a post that had been vacant since Prof. Reimarus had fled Hamburg during the siege. Lehmann brought with him from Goettingen about 2000 species of plants for his private garden. When a site for the new public botanical garden was found near the Dammthor, these plants were moved to the new garden. Lehmann himself planted the first tree November 6, 1821. He brought the Swiss Ohlendorff from Bern as chief

gardener. The quaint, straw-thatched cottage erected for Ohlendorff was still standing and in use in 1900.

Lehmann started the garden with a flurry of activity. Only two years later, in 1823, he sent out seeds of 5264 species and received 3609 packets of seeds and 2892 living plants. A coldhouse was built by public subscription in 1822. Lehmann continued his arduous duties for almost 40 years, not only as head of the garden but as the only professor of botany, and in addition at first he was obliged to teach zoology also. The number of species in the garden increased to 18,000 by 1848, and included many rare plants such as *Dryandra*, *Epacris*, *Borronia*, *Wallichia*, *Nepenthes*, and *Dionaea*. Lehmann found time to continue his researches on his favorite genus *Potentilla*, and also to publish ten parts of his "Pugilli," a series of papers describing interesting and new plants of the garden and herbarium. The later numbers of this were devoted almost wholly to Hepaticae.

After Lehmann's death in 1860, Heinrich Gustav Reichenbach (1824–1889) was appointed Director. He was the son of the famous botanist Heinrich Gottlieb Reichenbach, Professor of Botany in Dresden. The son was interested in orchids from the first, and contributed the account of the Orchidaceae to his father's "Icones Florae Germanicae et Helvetiae," on which he worked for ten years, with publication in 1851. He received his doctorate the next year by his thesis "De pollinis Orchidearum genesis ac structura," which brought about his appointment as lecturer in the University of Leipzig, where he was made Extraordinary Professor three years later. He won the position in Hamburg over five competitors.

On coming to Hamburg he made some fundamental changes, suspending the sale of plants to the public, eliminating the tree nursery and kitchen gardens, and starting a botanical museum. The plants in the garden had been arranged by the Linnaean system but he rearranged them by that of Endlicher, a much more meaningful arrangement. He began building up the collection again, purchasing the entire collection of the famous English gardener Saunders, of Reigate, Surrey.

Reichenbach continued his orchid studies, becoming the most famous—and indeed almost the only—orchidologist of his time after the death of Lindley. He published literally hundreds of papers in widely scattered journals, which included hundreds of new species. His name is usually abbreviated to "Rchb. f." by orchidologists, but this abbreviation is not in accordance with the rules as set forth in the Code. In this connection he travelled widely to various herbaria, often remaining for weeks or months. He was especially fond of Kew and planned on settling there after his retirement. He is reported by contemporaries to have been jealous of others working on orchids, which he considered a private preserve. In an obituary (Proc. Linn. Soc. Lond., August 1891) a colleague wrote: "A careful working of it [Reichenbach's herbarium] will be needed to clear up the many puzzles in his descriptions, which of late years had assumed an esoteric character. . . . The state of his herbarium is quite unknown, for during long years past no botanist has been permitted to have even a glimpse of the collection. . . . At his last visit to this country [England] Reichenbach was looking forward to his retirement . . . and the preparation of a projected Index Reichenbachianus, which was to give a much-needed guide to the widely scattered descriptions of species and varieties, but this last, if ever begun, is unfinished. At the Ghent Exhibition of 1888 it was noticed he was looking unwell and had shrunk from his accustomed portliness. By his death a gap is made which no man is likely to fill."

Reichenbach was an outgoing person, and his conversation was enlivened by witticisms and sarcastic remarks that were amusing to those who were merely onlookers and were not exposed to the brunt of his attacks. His sense of humor even carried over into his publications. He reported gleefully one story in the "Gardener's Chronicle:" It seems that a German entomologist described a butterfly under the name *Sesia longiformis*. Reichenbach wrote him that the name "*longiformis*" was improper (because "*formis*" means "having the shape or form of", as in "*loriformis*," having the shape of a strap, but "*longiformis*," having the shape of a "long" would be impossible). The entomologist dutifully renamed

his butterfly after the collector "*schmidtiformis*"! But Reichenbach had his detractors as well as admirers, and Hewitt Watson is said to have remarked that if Reichenbach's herbarium ever came into his control he would make a funeral pyre of it.

Reichenbach's chief claim to notoriety was his will, which even obtained notices in the newspapers, ordinarily unconcerned about the disposition of herbaria. In the London Evening Standard of June 5, 1889, appeared the following: "Professor Reichenbach's will is an event and a most disastrous one. It is indeed a scandal. That renowed herbarium which gave to Hamburg, in the eyes of botanists, somewhat of the sanctity that moslems attach to the city where the Kaaba stands, is not only diverted from the use and destination which savants all over the world expected, more than that it is withdrawn from the service of mankind for twenty-five years. We do not know that Professor Reichenbach was a naturalized Englishman, but his labours and his fame were associated with this country. It was taken for granted by men of science everywhere that the herbarium would go to Kew, and there is reason to think that he contemplated the bequest until very recent years. But neither Kew nor England is mentioned in the will. . . . Of course there is a story connected with this most unfortunate disposition—a story which is being discussed by all of the botanists of the world; but we would not dwell on it here. It is enough to say that the power of malicious individuals to damage the interests of the State is displayed in a striking manner."

The will in question left his herbarium to Vienna on the condition that it remained unopened and sealed for 25 years from his death; if Vienna would not accept it under these conditions, it was to be offered in turn to Uppsala, the Gray Herbarium, and Paris.

I do not know his reason for turning away from Kew. I asked Dr. John Hutchinson, who is the oldest working member of the Kew staff although of course not actively working in Reichenbach's time, but he did not know, other than to think that Reichenbach resented Rolfe having started to work on orchids at Kew. But I can guess at the reason for the peculiar provision in his will that the herbarium be sealed for 25 years. This coupled with the fact

that he would allow no visitors to see his herbarium shows clearly that it was filled with fragments from various herbaria, those jokingly called "kleptotypes." By having the herbarium used it would be soon obvious that fragments came from Kew and other herbaria. After a lapse of 25 years most of the persons in charge of herbaria would be dead or retired and in no position to state whether the fragments had been removed by permission or not. That this guess is true is shown by the contents of the herbarium when it was opened, although perhaps no one has ever commented on the fact. The herbarium was found to be tremendous, numbering more than 60,000 sheets of orchids and 8000 drawings. Almost all collectors of orchids are represented, including many from the late eighteenth century and early nineteenth, such as Pavon, Commerson, Humboldt and Bonpland, Chamisso, Blume, Bory, Haenke, Labillardière, Martius, Reinwardt, and Gaudichaud.[1] These specimens could hardly have come as duplicates to Reichenbach in such quantities and must have been removed from herbarium sheets, either with or without permission. This case is by no means unique. Christensen's fern herbarium purchased by the British Museum contains hundreds of fragments removed from various herbaria. The Underwood Herbarium, now in the New York Botanical Garden, contains hundreds of such "kleptotypes" also. The strangest case is that of Baillon, who worked at Paris for many years although not as a staff member. On his death his "type herbarium" went to Paris, where it is still maintained as a separate herbarium. It consists entirely of fragments removed from sheets in the Paris Herbarium, which is curious since the sheets in the Paris herbarium were freely available to him. These fragments really ought not to be considered the types of Baillon's new species but rather the full sheets from which they were removed. Baillon copied off the label data, and so the fragments can, at least usually, be matched up with the full sheets from which they were taken.

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[1] "Verzeichnis der im Orchideenherbare von Reichenbach fil. enthaltenen Sammlungen" by K. von Keissler and R. Rechinger. Ann. Naturhist. Hofmus. Wien **30:** 13–23. 1916.

Several years after Reichenbach's death Dr. Zacharias (born 1852 in Hamburg) became Director for many years. In 1901 all the botanical institutions were united to form the Botanische Staatsinstitut. In 1912 a separation was made into the Staatsinstitut für Angewandte Botanik, with Dr. A. Voigt named Director, and the Staatsinstitut für Allgemeine Botanik, which included the Botanical Garden and the Herbarium Hamburgense. Dr. Hans Winkler became the first Director of the Staatsinstitut für Allgemeine Botanik. He was a student of Wilhelm Pfeffer, under whom he received his Ph.D. in 1898, working on physiology. He was instrumental in setting up the University of Hamburg in 1919. His own research was on hybridization and parthenogenesis, and on apogamy and alternation of generations in ferns. He made collecting trips to the East Indies in 1903-4 and 1924–5. His extensive Bornean collections were still partly unworked in 1954 and probably still are; they have many undistributed duplicates also, I was told by Dr. Domke. Winkler retired during the War in 1943, when Hamburg was under constant attack. About sixty percent of the plants in the garden were destroyed by the bombing, but fortunately the herbarium escaped injury. Winkler died of a heart attack in 1945. In the same year Prof. Walter Mevius, a physiologist, was named Director. He was succeeded in 1964 by Prof. Horst Drawert, a cytologist and physiologist.

Dr. Edgar Irmscher, a specialist on *Begonia*, was named Curator of the Herbarium Hamburgense in 1912; he served in that post until 1945. Dr. Walter Domke succeeded Irmscher. Since 1961 Dr. Kurt Walther has been Curator. Other staff members of the herbarium of international reputation have been H. Hallier, who worked on Convolvulaceae, and C. Grimme, who worked chiefly on economic plants.

THE HERBARIUM

In the early years of the botanical garden there was no official herbarium. The Director, Lehmann, put all the specimens received in his personal herbarium, a practice common enough at one time but one to be deplored. Specimens that come to botanists

officially connected with an institution ought to be considered institutional property, and so they are today usually. But Lehmann's herbarium was divided up into 150 different lots, which were individually sold and dispersed. We do not know today what it contained or where it went, and we are even more ignorant about it than about the herbaria of Kurt Sprengel or of Lambert, which were similarly broken up. It is perhaps not an easy matter to locate Lehmann's types today.

The beginning of the permanent herbarium was the gift of the private herbarium of H. W. Buek, of Hamburg, in 1864, which contained about 10,000 specimens. About the same time the algal herbarium of Nikolaus Binder was also donated. This is a large and important collection containing types or isotypes collected or described by Mertens, Tilesius, Agardh, Lyngbye, Raben, Hering, Montagne, Lindenberg, Rudolphi, Weber and Mohr, and many others. A little later the herbarium of the private Museum Godeffroy, built up by the Godeffroy family, was acquired. This contained the original collections of Graeffe, Amalie Dietrich, Kleinschmidt, and others who had been sent on expeditions by Godeffroy. The Graeffe collections are important for fern students, being the basis for Luerssen's "Filices Graeffeanae."

The Buek and Binder herbaria were united in 1879, which is considered the official start of the present herbarium. Richard Sadebeck took over as custodium in 1882, and A. Voigt became his assistant. The herbarium grew rapidly until at the last estimation it contained 700,000 specimens. Sadebeck brought his own herbarium, mostly of European plants but containing also some exotics, such as Chilean specimens from Philippi. The grass herbarium of Klatt was acquired, and Willkomm's algal herbarium. But the largest accessions were of plants from Africa. The oldest of these and perhaps the most important were the South African collections of the Drège brothers Jean and Carl, who were born near Hamburg and who went to the Cape in 1826. They collected extensively, travelling by ox-cart to the mouth of the Orange River in the west and to Port Natal (Durban) in the east, finding more than 7000 species, about two-thirds of

all those that had been previously known in South Africa. The principal collections were in Berlin and were destroyed in World War II; there are only a few in Hamburg. Later Jean Drège was joined by Christian Friedrich Ecklon and Karl Zeyher, and the three of them continued to make extensive collections which were brought back to Hamburg to be studied in the nursery that the Drège family owned in Hamburg. Drège published a "Catalogus plantarum exsiccatarum Africae australioris" in Hamburg (1837–40), and Ecklon and Zeyher a more extensive scientific paper, "Enumeratio plantarum Africae australis extra tropicae," in three parts (1834–37). Many of the Ecklon and Zeyher plants were worked up by Otto Wilhelm Sonder. Sonder (born in Holstein in 1812) worked as a pharmacist for a living, but apparently all his spare time was spent on botany. He achieved an international reputation by his papers on *Salix*, on the algae of Australia collected by Preiss, and especially on the South African plants of Drège, Ecklon, and Zeyher, on which he worked with his friend Prof. William H. Harvey, of Dublin. The two were both interested in algae and proved congenial workers. Together they produced the fine three volumes of the "Flora Capensis," published in 1859-1865. The work was left incomplete by the death of Harvey, but it is still a classic work on the South African flora. Sonder's personal herbarium, the algae at least, was sold and is now partly in Stockholm and partly in the National Herbarium of Victoria, Melbourne.

The more recent African collections constitute perhaps the most important part of the herbarium. They include the original set of Kurt Dinter's plants from Southwest Africa, the Max Julius Dinklage specimns from western Africa, especially Liberia and Gabon, the Mildbraed collections from Cameroons (the 3500 numbers of which are most important since the destruction of the first set in Berlin), plus collections by Fischer from Zanzibar, Stuhlmann from Mozambique (but not Tanganyika), Lindinger from the Canary Islands, and many others. A full account of the African collections has been published by Kurt Walther in his paper "Afrikanische Pflanzen in Hamburg, Hamburger Botaniker

in Afrika" (Mitt. Geogr. Gesell. Hamburg **56:** 87–103. 1965). The collections in the general herbarium are far too numerous to begin to enumerate them.

PUBLICATIONS

The early works of the staff at Hamburg were partly published in the "Jahrbuch der Hamburgischen Wissenschaftlichen Anstalten," between 1889 and 1913, which was not however restricted to botany. The present serial publication is the "Mitteilungen aus dem Institut für Allgemeine Botanik in Hamburg," volume 1 of which appeared in 1914. The most important volumes in a taxonomic way are volume 7, which consists of the "Beiträge der Flora von Borneo," a systematic treatment by families of the specimens collected by Winkler, with contributions by Diels, Kränzlin, Brotherus, Pfeffer, Pilger, Merrill, J. J. Smith, Christensen (on the ferns), and Alston (on the Selaginellas). The introduction contains a map of Winkler's itinerary. Volume 10 (1939) is a "Festschrift" for Hans Winkler on his 60th birthday; the principal paper is a "Flora des tropischen Arabien," by O. Schwartz; I am not quite sure whether the material on which this paper is based is preserved in Hamburg or not, but it probably is, in which case Hamburg would be a necessary visit for anyone interested in the Arabian flora. This journal was interrupted by the war and did not resume publication until 1957. Only two volumes have been issued since then.

The "Hamburger Garten und Blumenzeitung" was perhaps not quite an official publication, but it was closely associated with the botanical garden through its editor, Carl Friedrich Eduard Otto (1812–1855), usually called merely Eduard Otto. Otto was the son of the famous gardener of the Berlin Botanical Garden, Christian Friedrich Otto, and so he came by his gifts naturally. He started in as an assistant to his father in Berlin, but after the retirement of Ohlendorff he was chosen to come to Hamburg by Lehmann to be the head gardener, a post that he held for about 40 years. The journal mentioned above was a gardening publication, noticing plants new to cultivation and so forth, very

similar in content to the "Gardener's Chronical" concurrently being published in England. Otto took over as editor with volume 4 (1848) and continued through volume 40 (1884, the year before his death), altogether 37 volumes each with about 575 pages, with a total of over 21,000 pages. Since Otto did all the writing apparently, it is certain that he must have been industrious. The publication, like so many others, did not last long after Otto's death. This journal contains notes on many plants new to cultivation and may contain some new names, although perhaps not intentionally with Latin descriptions. There *are* ferns discussed, but I am sure that no one has ever looked through the volumes to see if any are new, nor is anyone likely to. The journal is by no means easy to read, being in cursive German type (except for the plant names in Roman type), and I have some doubt that many people ever actually read it even when it was being published. There is a portrait of Otto as a frontispiece to volume 41 of this journal, and a biography by F. Goeze (who took over as editor).

FERNS IN HAMBURG

The pride of the fern herbarium according to A. Voigt is the Prantl herbarium purchased after Prantl's death. Karl Prantl was born September 10, 1849, in Munich. He received his doctorate from Munich in 1870 under Naegeli and Radlkofer. With his friend Lorentz, who later went to Argentina to teach and collect, he botanized in Bavaria and the Alps, and then spent a year as Naegeli's assistant. In 1873 he was assistant to Sachs, with whom he worked on the regeneration of the growing point in angiospermous roots. At Sachs' invitation he adapted some of Sachs' works into a "Lehrbuch der Botanik" (1874), which became popular as a text in secondary schools and which went through many editions. In 1879 Prantl turned his attention to ferns, being at this time a professor in Aschaffenburg. His principal work in this field is his "Untersuchungen zur Morphologie der Gefässkryptogamen," I. "Die Hymenophyllaceen" (1875) and II. "Die Schizaeaceen" (1881). Prantl considered the Hymenophyllaceae the lowest group of ferns from a developmental point

of view. Subsequently, he worked on *Cryptogramma*, *Pellaea*, and *Ophioglossum*, and his very last paper in 1892 was on fern classification. From 1889 until his death from tuberculosis in 1893 he was professor in Breslau. Adolf Engler evidently had a high regard for his talents, for he asked Prantl to join him in a vast undertaking, a complete treatment of all the genera of plants, cryptogams as well as vascular plants, something that had hardly been attempted since the time of Linnaeus. The work was to be called "Die Natürlichen Pflanzenfamilien," and Prantl was to be in charge of the cryptogamic portions. Prantl accepted willingly and began work at once, not on the cryptogams but on the early families of angiosperms according to the new system proposed by Engler. Prantl himself had no part in the elaboration of this system, which is now commonly called the Engler and Prantl system. The basic ideas of this arrangement of the families came from Eichler and were modified by Engler in his "Syllabus der Pflanzenfamilien." Prantl worked up the Betulaceae, Fagaceae, Magnoliaceae, Anonaceae, Ranunculaceae, Berberidaceae, Cruciferae, and other families in short order, and it is apparent that had he lived he would have done a major part of the writing himself, something that Engler himself never did. Engler secured the cooperation of many botanists, chiefly German, to complete the work. Although Prantl died shortly after the start of the work, his name remained on the title page throughout.

I have myself never had a high regard for Prantl's work on ferns. His idea of applying morphology and anatomy to taxonomic classification is certainly proper, but he seemed to lack the eye for distinguishing species which is a necessity for a good taxonomist. I, at least, have never found his systematic contributions useful or usable. I am not sure about the size or quality of his fern herbarium. Hamburg has many valuable old fern specimens, and many of these *may* have come from Prantl.

Among the notable collections are those of Graeffe from the South Seas (original), Poeppig (Chile, Peru, and Cuba), Pohl (Brazil, probably including Presl isotypes), Philippi (Chile), Deppe (Mexico, isotypes of Schlechtendal), Daemel (Fiji), Sellow (Brazil,

many isotypes), Wawra, Zollinger (Java, Kunze isotypes), Haenke (Presl isotypes), Sieber (Kaulfuss isotypes), Gueinzius (South Africa, Kunze isotypes), and too many others to mention. One of the important sets is that of Karsten from Colombia and Venezuela. This set is so complete, the sheets so full (sometimes two and three sheets of the same collection), and the labels so complete that I wonder if this is not the original set. It should be compared with the sets in Leningrad and Vienna. Another notable set is from the botanical garden in Berlin of the early cultivated ferns described by Link; so far as I can tell, these match closely the comparable specimens in Berlin, and can be considered as authentic material of Link's species if not actual isotypes.

There has never been in Hamburg a pteridologist of international reputation except Richard Sadebeck, who was professor and custodian of the herbarium in the 1890's and 1900's. Sadebeck had many interests, including ferns. Engler chose him to write the general account of the Pteridophyta for "Die Natürlichen Pflanzenfamilien," and Sadebeck also contributed the accounts of the Hymenophyllaceae, Marsileaceae, and Salviniaceae to this work. Dr. C. Brick, assistant in the herbarium for many years, was also a fern man, and contributed the fern reports in Just's "Botanischer Jahresbericht" from about 1894 to 1910.

I visited the fern herbarium in Hamburg only briefly, for three days in 1954. I was cordially received by Dr. Domke, then the curator and was made to feel welcome. The herbarium was rather crowded at that time, a perennial complaint of almost all herbaria. I did not go to look up anything in particular but merely to get an idea of the scope of the fern collections. I was pleasantly surprised, for the herbarium is indeed rich, and should be visited more often by fern students.

I am much indebted to the present curator, Dr. K. Walther, and to the Chief Custodian, Dr. P. Wiemann, for helpful information. My chief source for the historical part of this account is "Die botanischen Institut der freien and Hansestadt Hamburg," by A. Voigt (1897).

(To be continued)

Fertile Sporophytes of Botrychium virginianum Attached to Gametophytes[1]

BRUCE W. MCALPIN

While making a floristic survey of the pteridophytes of the Highlands, North Carolina area (Macon County) with Dr. Warren H. Wagner, Jr., I discovered a population of *Botrychium virginianum* containing many small but fertile specimens. An apparently similar population has been described for the Mountain Lake (Giles County) area in Virginia (Wagner, 1963, pp. 130–131.) Investigation of the Macon County plants showed a considerable percentage of the plants attached to large gametophytes. Whereas juvenile plants typically are found attached to a gametophyte (Bierhorst, 1958), the plants found near Highlands showed a wide range of developmental stages. Many were fully fertile with small leaves 3–5 cm broad (*Fig. 1*). These juvenile specimens have had the name *B. virginianum* var. *gracile* (Pursh) Lawson applied to them, but are not worthy of taxonomic recognition (Weatherby, 1935). Precociously fertile sporophytes may be due to abundant nutrition supplied by long-lived gametophytes.

Gametophytes of most ferns usually die after the sporophyte has become self-sufficient. This is not strictly the case in the eusporangiate genus *Botrychium* where gametophytes have been reported still attached to sporophytes at least two years old (Foster, 1964) and up to eight years old (Jeffrey, 1896–97, pp. 271–272). Campbell (1911, p. 18) mentions that fertile *B. virginianum* sporophytes with attached gametophytes were found by Jeffrey, but similar plants are not mentioned by later workers.

Bierhorst (1958) believes that a relatively small number of gametophytes persist after giving rise to a sporophyte. He states that in areas where sporophytes of all ages are present it is not the older sporophytes with attached gametophyte which predominate,

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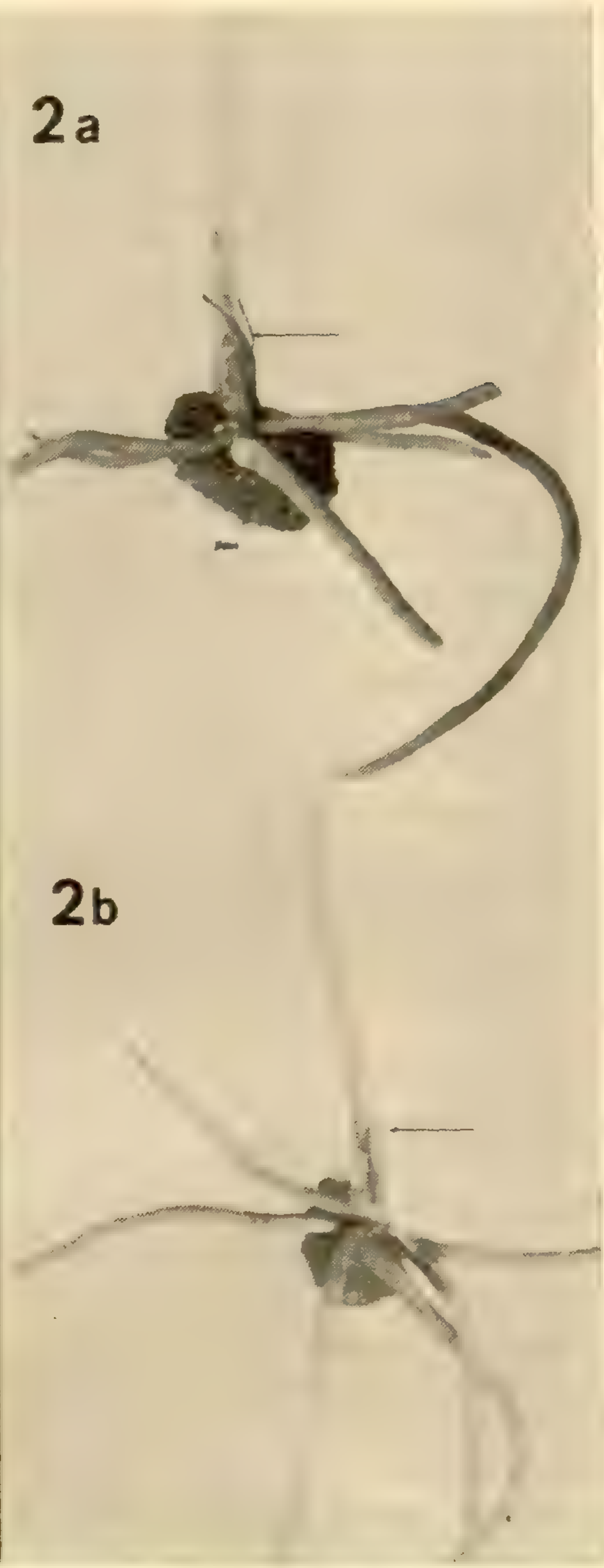
[1] This research was supported by NSF grant GB-2496 to the Highlands Biological Station. Voucher specimens (*Wagner 69100*) are on deposit in the herbaria of the University of Michigan and Duke University.

but rather the very young ones. The Highlands population of *B. virginianum* that was collected in July, 1969, contained plants in which 60% of the sterile and fertile sporophytes were attached to large, long-lived gametophytes. In this population gametophyte retention appears to be common. The attached gametophytes were 3–14 mm long and the largest were attached to fertile sporophytes (*Fig. 2*).

Very large gametophytes could supply abundant nutrients to first-year sporophytes, which then could grow larger than average and perhaps become fertile. The largest sporophytes had three to six roots and often retained the shriveled bases of previous leaves. Since a single root and leaf typically are produced annually by *Botrychium* sporophytes, this indicates that the sporophyte developed attached to the gametophyte for a number of years.

Nutritional aspects of the gametophyte and its symbiotic fungus have not been adequately investigated. However, the presence of stored starch in the gametophyte is evidence that the symbiotic process is efficient. This food reserve is presumably used by developing embryos and young sporelings before the sporophyte has become self sufficient. Conceivably the stored material and even the symbiotic metabolism of the gametophyte and fungus may be beneficial to the sporophyte throughout its life history. This appears to be the case in some *Botrychium* plants with long-lived gametophytes.

Factors which cause gametophyte retention are unknown but appear to be frequent since most collections of *Botrychium* gametophytes contain individuals with attached sporophytes (Bierhorst, 1958). In many large populations of *Botrychium* there is much variation in leaf size. A gametophyte is often attached to the smallest plants (leaves 1–2 cm broad). Occasionally several hundred sporelings with attached gametophytes can be collected in an area of a few square feet. Careful sifting and washing of the soil over a fine mesh screen may yield gametophytes in all stages of development. Pteridologists interested in securing gametophytes of *Botrychium* species for study or teaching material need only look for the smallest sporophytes in or near large popu-



Fertile Botrychium virginianum Sporophytes with Attached Gametophytes. Fig. 1. Habit of plant, × 0.8. Figs. 2a, b. Gametophytes attached to sporophytes with multiple roots and dead leaf bases (arrow), ca. × 1.

lations. Careful search of the surrounding soil may then yield an entire ontogenetic series of the subterranean gametophytes.

LITERATURE CITED

CAMPBELL, D. H. 1911. The Eusporangiatae. Carnegie Inst., Washington, D.C.

BIERHORST, D. W. 1958. Observations on the gametophytes of Botrychium virginianum and Botrychium dissectum. Amer. J. Bot. **45**: 1–9.

FOSTER, D. B. 1964. The gametophyte of five species of Botrychium. Ph.D. thesis, Cornell University.

JEFFREY, E. C. 1896–97. The gametophyte of Botrychium virginianum. Trans. Canad. Inst. **5**: 265–294.

WAGNER, W. H., JR. 1963. Pteridophytes of the Mountain Lake Area, Giles County, Virginia, including notes from Whitetop Mountain. Castanea **28**: 113–150.

WEATHERBY, C. A. 1935. A list of varieties and forms of the ferns of eastern North America. Amer. Fern J. **25**: 95–100.

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A Peculiar Species of Grammitis

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Polypodium matheusii Kunze ex Mett. was described from Peruvian specimens collected by Mathews; the locality was not specified but was given by Hooker (Sp. Fil. **5**: 20. 1864) as Chachapoyas, and the numbers as *Mathews 1811* and *3281*. However, it is evident that Mathews collected this species at least three times, all at Chachapoyas, for the specimen in the British Museum is no. *1837*. The holotype in Kunze's herbarium has been destroyed. A specimen of one of these numbers in the Mettenius herbarium in Berlin should be designated as lectotype, if one exists, other-

wise one of the Kew specimens should be the lectotype. Hooker stated that the specimens had long been preserved in his herbarium as a new species.

This peculiar and distinctive species was placed by Mettenius and by Hooker among the Goniophlebiums because of its venation, but it is quite different in its general aspect—thick texture, long-decurrent segments with the lowest veinlet arising from the costa, and especially by the setiform hairs, which are exactly like those typical of many species of *Grammitis*. An examination of the spores shows that they are trilete, and that therefore this is truly a species of *Grammitis* sect. *Cryptosorus*. It is the only known species of this section with more or less completely goniophlebioid venation. The segments have a single, incomplete row of costal areoles, with one included veinlet. However, unlike the true Goniophlebiums, the sorus is dorsal on the included veinlet and not terminal. This venation pattern is an extension and complication of the type of venation found in *Grammitis* **kalbreyeri** (Baker) Morton, comb. nov. (*Polypodium kalbreyeri* Baker, Trans. Linn. Soc. II, Bot. **2**: 291. 1887) and some other large species of *Grammitis*. It is to be expected that when segments become broad that anastomoses can occur, a phenomenon well known within *Polypodium* sect. *Polypodium* (including *Goniophlebium*) and *Polypodium* sect. *Marginaria*. This is not the only instance of anastomosing veins in *Grammitis* sect. *Cryptosorus*, either, for anastomoses are occasionally found in *G. eminens* Morton and *G. trifurcata*, and rather uniformly in *G. crispata* (J. Smith) Morton. However, none of these species seem at all allied to *Polypodium mathewsii*, which should be known as *Grammitis* **mathewsii** (Kunze ex Mett.) Morton, comb. nov. (*Polypodium mathewsii* Kunze ex Mett. Abhandl. Senckenb. Naturf. Gesell. **2**: 74. 1856). The relationship of this species must remain undetermined at present; very likely it is an isolated type that might constitute a section by itself.

There may be some relationship to such species as *Grammitis* **albidula** (Baker) Morton, comb. nov. (*Polypodium albidulum* Baker in Mart. Fl. Bras. **1**(2): 598. 1870) and *Grammitis* **discolor**

(Hook.) Morton, comb. nov. (*Polypodium discolor* Hook. Icon. Pl. **4:** *t. 386*. 1841), which differ in having the blades ceraceous beneath, and the veins forked but not anastomosing. In *G. mathewsii* the blades are green beneath and not white-waxy.

Grammitis mathewsii is widespread; it has been known from Colombia to Peru, and may now be reported from Bolivia also. According to Hooker, *Goniophlebium villeminianum* Fée (Mém. Foug. **7:** 63, *t. 27, f. 3*. 1857) is a synonym, and from Feé's figure this would seem to be correct. However, Fée described and illustrated some clathrate scales that are said to occur on the lower surface, and I have not found such scales in the material I have studied, nor indeed are they to be expected in this genus. Fée's statement may have been an error of observation. His species came from páramos above Ocaña, Norte de Santander, Columbia, at 3400–3700 m. elevation, where it had been collected by Schlim. I have seen a specimen from the Páramo del Hatico, Norte de Santander, which must not be very far away, and this agrees well with Fée's description and figure.

SPECIMENS EXAMINED:

COLOMBIA: Páramo del Hatico, Norte de Santander, alt. 290 m, *Killip & Smith 20686*. Near Facatativa, Cundinamarca, under rocks, *Ariste-Joseph A405*. Páramo de Guasca, above Bogotá, Cundinamaraca, *Ariste-Joseph A344, A477*. Bogotá, alt. 3,200 m, *Lindig 178* (BM). Without locality, *Mutis 3228*.

ECUADOR: Near the laguna, Páramo del Castillo, crest of the eastern cordillera on the trail between Sevilla de Oro and Mendez, Azuay, epiphyte, alt. 2,700–3,300 m, *Camp E5108*.

PERU: Pendent from tree branches or rocks, frequent, moist ravine head on middle eastern Calla-Calla slopes, 3–5 km. SE of km 422 on the Leimebamba—Balsas road, Prov. Chachapoyas, Amazonas, alt. 3,000–3,200 m, *Wurdack 1765*; same, near km 415–418, alt. 2,900–3,150 m, *Wurdack 1743* (these two collections from somewhere near the type locality). Alturas de Sucre, Cuzco, alt. 3,000 m, *Bues 1538*. Montaña de Calea, Valle de Nares, Cuzco, alt. 2,250 m, *Bues 1924*. Chachapoyas, *Mathews 1837* (BM).

BOLIVIA: Valle de Corani, Cochabamba, alt. 800 m, epiphyte, July 6, 1968, *Adolfo 103*.

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Vascular Organization of the Rhizome of Cibotium barometz

SUBHASH CHANDRA[1]

Cibotium is a genus of about a dozen species distributed in southeastern Asia, Hawaii, and Central America. Some of the species are large and rather resemble tree ferns. *Cibotium barometz* is a graceful, large, Malaysian fern with a stump-like rhizome 5–8 cm. in diameter that appears much stouter because of its crowded, persistent leaf bases. Its rhizome is the "Vegetable Lamb" or "Scythian Lamb" of the Orient. The rhizome, which is densely clothed with large, tufted, golden brown hairs and hence appears like a wooly lamb, is semi-erect and bears a crown of large, bipinnate fronds 2–3 m. long that are covered with similar hairs at their base. These profusely produced hairs are used for stuffing cushions and pillows and are reputed to staunch a bleeding wound.

Most pteridologists believe *Cibotium* is cyatheoid (Mettenius, 1856; Diels, 1899; Manton, 1958; Holttum and Sen, 1961; Nayar, 1970), but others think it is related to the dennstaedtioid ferns (Bower, 1926; Christensen, 1938; Copeland, 1947). The anatomy of the Cyatheaceae, including some of the species of *Cibotium*, has been studied recently by Holttum and Sen (1961) and by Sen (1964), who have pointed out the significance of rhizome anatomy in assessing the phylogenetic relationships of these ferns. Some aspects of the anatomy of *C. barometz* were reported by Ogura (1926, 1930), and some details of the vascular organization were discussed by Hayata (1929). On the basis of the stelar structure, the latter separated *C. barometz* as a subgenus, *Microcibotium*.

This study is based on material collected from Naphuk, Assam (*P. & S. Chandra 72165*, LWG). The anatomy was studied from microtome sections of material fixed in F.A.A., stored in 70% ethyl alcohol, and stained with combinations of safranin and either fast green, sudan IV, or iodine.

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[1] I am indebted to Dr. B. K. Nayar, National Botanic Gardens, Lucknow, for his guidance, encouragement, and discussions, and to Mr. P. C. Roy for his help in making the illustrations.

The rhizome is soft and is bounded by a thin-walled epidermis; 20–30 layers of hypodermal cells form a sheath composed of narrow, slightly elongated cells having faintly thickened walls. The ground tissue cells are thin-walled and parenchymatous, and contain dense starch deposits. Numerous cells containing mucilage are scattered in the parenchyma. The vascular cylinder (*Fig. 2*) is a large solenostele (the pith is often 4–6 cm. in diameter) pierced by small, subovate, spirally arranged leaf gaps (*Fig. 2*, g); because the leaves are crowded, the leaf gaps are often so closely placed that the vascular cylinder approaches the dictyostelic condition. No medullary vascular tissue is found. Each leaf (*Fig. 2*, l) is supplied by a large, corrugated, gutter-shaped vascular strand given off from the lower end of the leaf gap. Before separation from the stelar cylinder, the leaf trace forms a broad, prominent, hollow, outward protrusion which extends some distance below the leaf gap. These protrusions make the cylinder irregularly corrugated. The leaf trace bundle, although a solitary band at its origin, divides into a large number of narrow strands before entering the leaf base. The strands are arranged in the form of an open gutter with incurved margins and a longitudinal, lateral invagination near each adaxial margin. The strands are disposed in three groups (*Fig. 1*). One forms a broad, abaxial arch with incurved margins facing the center; the other two are smaller, adaxial, more sharply curved arches with the concavity facing away from the center. The leaf trace maintains this shape as it passes up the stipe. The roots are mostly associated with the leaves, and the root traces are given off in clusters (*Fig. 2*, r) just before the leaf trace separates from the stelar cylinder.

The xylem tissue of the vascular cylinder is composed of 6–12 layers of broad, short, scalariform tracheids interspersed with narrow, ribbon-like, interconnected bands one cell thick that are mostly arranged radially and composed of thin-walled xylem parenchyma cells. Phloem surrounds the xylem on either side as a thin layer composed of two or three layers (one or two only on the abaxial side). The phloem consists of narrow, thin-walled tracheids mixed with parenchyma cells. There is a peripheral

Anatomical Details of Cibotium barometz

layer 3–5 cells broad of tangentially much elongated, narrow, thin walled cells (*Fig. 3*, t) surrounding the phloem, as is characteristic of the cyatheoid ferms (Holttum and Sen, 1961; Sen, 1964). These cells stain deeply with fast green, are devoid of nuclei, and possess scattered sieve areas on all walls (Ogura, 1927; Holttum and Sen, 1961; Sen, 1964). This layer of tangential cells gives a characteristic appearance to the vascular cylinder in cross-section. The pericycle is two- or three-layered. The endodermis is poorly differentiated, but is demarcated from the much larger cells of the ground tissue. Cubical cells and sclerenchymatous bands, as reported in some of the Cyatheaceae (Holttum and Sen, 1961), are absent. The leaf trace bundle is structurally similar to the main vascular cylinder, but the xylem tissue is thinner and contains only 1–3 layers of tracheids; tangential cells are absent, and the endodermis is better differentiated.

Vascular anatomy of the rhizome of *C. barometz* lends support to the hypothesis that it is related to the cyatheoid ferns. The leaf trace bundle and its relationship to the main stelar cylinder are similar to those reported in *Cyathea* and related genera. The characteristic tangential cells surrounding the phloem tissue in *C. barometz* are paralleled in the cyatheaceous genera and constitute a characteristic anatomical feature of that group, but are not found in the demstaedtioid ferns. Also, the vascular cylinder of *C. barometz* is radially symmetrical with spirally arranged leaf gaps, as in the cyatheoid ferns, in contrast to the dorsiventral stele of the demstaedtioids (Kaur, 1962; Nayar and Kaur, 1963a, b), which have the leaf traces arranged in two dorsal rows, with leaf gaps lateral to them on the side facing the median plane of the rhizome.

FIG. 1. CROSS-SECTION OF VASCULAR STRANDS AT LEAF BASE. FIG. 2. PORTION OF STELAR CYLINDER OF THE RHIZOME. FIG. 3. CROSS-SECTION OF A PORTION OF THE VASCULAR CYLINDER OF THE RHIZOME. The abbreviations are: c = CORTICAL CELL, e = ENDODERMIS, g = LEAF GAP, l = LEAF TRACE, m = MUCILAGE-CONTAINING CELL, p = PERICYCLE, ph = PHLOEM, r = ROOT, t = TANGENTIAL CELL, x = XYLEM, xb = XYLEM PARENCHYMA BAND.

LITERATURE CITED

BOWER, F. O. 1926. The Ferns, vol. 2. University Press, Cambridge.

CHRISTENSEN, C. 1938. Filicinae *in* F. Verdoorn, Manual of Pteridology. M. Nijhoff, The Hague.

COPELAND, E. B. 1947. Genera Filicum. Chronica Botanica, Waltham, Mass

DIELS, L. 1899. Cyatheaceae *in* A. Engler & K. Prantl, Die Natürlicher Pflanzenfamilien **1(4)**: 113–139.

HAYATA, B. 1929. Microcibotium, a new subgenus founded through the consideration of the stelar structure of Cibotium barometz. Bot. Mag. Tokyo **43**: 312–317.

HOLTTUM, R. E. and U. SEN. 1961. Morphology and classification of tree ferns. Phytomorphology **11**: 406–420.

KAUR, S. 1962. Morphological and anatomical investigations on ferns: Bolbitis, Egenolfia and related Ferns. Ph.D. Thesis, Agra, University.

MANTON, IRENE. 1956. Chromosomes and fern phylogeny with special reference to "Pteridaceae." J. Linn. Soc. London, Bot., **56**: 73–92.

METTENIUS, G. 1856. Filices Horti Botanici Lipsiensis. L. Voss, Leipzig.

NAYAR, B. K. 1970. Scheme for a phylogenetic classification of the homosporous ferns. Taxon **19**: 229–236.

———, and S. KAUR. 1963a. Contributions to the morphology of some species of Microlepia. J. Indian Bot. Soc. **42**: 225–232.

———, and ———. 1963b. Ferns of India—VIII. Microlepia Presl. Bull. Nat. Bot. Gards., Lucknow **79**: 1–25.

OGURA, Y. 1926. On the structure and affinity of Cibotium barometz Sm. Bot. Mag. Tokyo **40**: 349–359.

———. 1927. Comparative anatomy of Japanese Cyatheaceae. J. Fac. Sci. Imp. Univ. Tokyo **1**: 141–350.

———. 1930. On the structure of Hawaiian Tree Fern with notes on the affinity of the genus Cibotium. Bot. Mag. Tokyo **44**: 467–478.

SEN, U. 1964. Importance of anatomy in the phylogeny of tree ferns and their allies. Bull. Bot. Soc. Bengal **18**: 26–33.

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A Survey of Some Morphological Features of the Genus Elaphoglossum in Costa Rica

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The systematics of the over 400 species of *Elaphoglossum* (Aspidiaceae) is as little known or understood as any large genus of tropical ferns. Although the genus as a whole is pantropical, the majority of species are found in the Neotropics, an area in need of much botanical exploration. Endemism appears to be extremely common. A plethora of forms occupy similar habitats in the same region and many occur side by side on tree trunks and branches. Until much additional field work is done in the New World tropics, many of the species in the genus will remain undescribed.

Bell (1950; 1951a, b; 1955; 1956) initiated a series of morphological studies in the genus *Elaphoglossum* dealing with stelar structure, root and bud traces, and anatomy of the rhizome and frond. In these studies he made no attempt to correlate form with habitat. During the summer of 1967, I undertook a somewhat similar study in Costa Rica to add to our knowledge of morphology in the genus, as well as to correlate this with the basic habitat.

Plants were collected in seven geographical locations throughout Costa Rica: Peninsula de Osa (0–500 m elevation), San Ramón (1000 m), San Vito de Java (1100–1400 m), Volcán Poás (1800–2650 m), Volcán Barba (2200 m), Cerro de la Muerte (1200–3350 m), and Finca La Selva, south of Puerto Viejo (100 m). The habitats represented by these areas vary from Pacific and Atlantic lowland tropical wet forest to cloud forest, montane rain forest, and mossy elfin forest. Observations were made on the following characters: petiolar joints and swellings, pneumatophores, laminar scales, and sporangial features including paraphyses, number of indurated annular cells, and the presence or absence of chlorophyll in the sporangial stalk.

The data have been grouped according to plant habitat (epiphytic, epiphytic and terrestrial, terrestrial) and elevation (0–1000 m, lowland rain forest; 1000–2500 m, mid-elevation wet and

dry forest; and above 2500 m, high elevation wet forest). The climates of these areas are discussed by Scott (1966).

The data presented here represent only a summary of that collected. Mimeographed sheets with full results will be provided by the author on request. Voucher specimens have been deposited in the herbarium of the New York Botanical Garden. About 80 species were investigated, 70 in detail. Some of these are undescribed and the relationships of many others are in doubt.

TABLE I. HABITAT OF ELAPHOGLOSSUM BY ELEVATION

	Number of species and percent					
Elevation	*epi-phytic*	*%*	*terr. & epi.*	*%*	*terres-trial*	*%*
0–1000 m	13	93	0	0	1	7
1000–2500 m	29	76	0	0	9	24
above 2500 m	14	50	4	14	10	36
0–2500 m	42	81	0	0	10	19
Total	56	70	4	5	20	25

RESULTS

Habitat.—Of the 80 species of *Elaphoglossum* studied, 56 (70%) were epiphytic. There is a direct correlation between increasing elevation and frequency of terrestrial habit. At elevations below 1000 m, over 90% of the species were epiphytic, but above 2500 m only 50% occupied this habitat (*Table I*). In addition, those occupying both terrestrial and epiphytic habitats were found only at higher elevations.

Petiole Characters.—There is distinct variation in the petioles in *Elaphoglossum*. At the base of the petiole in the region where abscission occurs there may occur a joint or swelling. The joint refers to a point where there is a distinct color change where the petiole and phyllopodium join. This may or may not be accom-

panied by a slight swelling of the region (see Bell, 1955, *fig. 4.*). Of the 70 species investigated, 59 exhibited a distinct color change from petiole (usually green) to phyllopodium (usually dark brown or black). In 54 of these the joint was accompanied by swelling. Only five species possessed joints without swelling: *E. eximium* (Mett.) Christ, *E. aff. lindenii* (Bory) Moore, *E. muscosum* (Swartz) Moore, *Lloyd 4219*, and *Lloyd 4220*. The eleven species which were unjointed did not possess swellings. These results are similar to those of Bell (1955), who found a close association between the two characters with but only one exception.

Terrestrial species exhibited a greater frequency of joints and swellings than epiphytic (*Table II*), and those from middle elevations appeared to have a greater frequency with both structures than those from either lowland or highland areas (*Table IV*).

Pneumatophores.—Aerenchymatous flanges (or pneumatophores) are composed of loose, parenchymatous cells with large air spaces; they usually extend as a flange through the sclerified outer cortex of the phyllopodium. Bell (1955, *fig. 4*) recognized several types. They vary from narrow, lenticel-like lines extending from the base of the phyllopodium to the petiole to elaborate wing-like or phalloid structures of various sizes. They have been found in 92% of the species in Costa Rica, with the most frequent types being either a wavy, linear and somewhat fleshy tissue about 1–2 mm broad extending the length of the phyllopodium (Type C), found in 39% of the species, including *E. erinaceum* (Feé) Moore, *E. aff. hirtum* (Swartz) C. Chr., *E. hyalinum* Christ, *E. aff. lindenii* (Bory) Moore, *E. muscosum* (Swartz) Moore, and *E. aff. tectum* (Humb. & Bonpl.) Moore; or a phalloid structure about 2–4 mm long and 1–2 mm wide, arising from and restricted to the region near the base of the phyllopodium (Type G). This type of pneumatophore is always associated with densely scaly rhizomes and is found in 18% of the species, including *E. conspersum* Christ, *E. herminieri* (Bory & Feé) Moore, *E. longifolium* (Jacq.) J. Smith, *E. revolvens* (Kunze) C. Chr., and *E. squamipes* (Hook.) Moore. The most common type of pneumatophore (C) occurs in 46% of the epiphytic species and only 15% of the terrestrial. Type G is

TABLE II. PERCENT OF SPECIES WITH CHARACTERISTICS IN RELATION TO EPIPHYTIC, TERRESTRIAL AND EPIPHYTIC, AND TERRESTRIAL HABITAT

	Habitat			
Character	*epiphytic*	*terr. & epi.*	*terrestrial*	*Mean*
Swelling	78	50	85	71
Jointed	80	75	95	80
Pneumatophore[a]				
Type A	4	0	20	9
B	12	0	5	8
C	46	75	15	39
D	4	0	15	7
E	6	0	10	7
F	13	0	10	11
G	15	25	25	18
Scales: adaxial				
Glabrous	50	25	60	52
Type A (*fig. 8–1*)[b]	2	0	0	1
B (*fig. 7*)	14	25	5	12
C (*fig. 8–7*)	14	25	30	19
D (*fig. 8–10*)	7	0	0	4
E (*fig. 8–11*)	13	25	5	12
Coverage:				
Under 10%	80	25	80	77
10–40%	15	75	15	19
Over 40%	5	0	5	4
Scales: abaxial				
Glabrous	14	0	20	15
Type A	2	0	0	1
B	9	0	10	9
C	52	25	50	50
D	7	50	5	9
E	16	25	15	16
Coverage:				
Under 10%	80	50	85	79
10–40%	2	0	0	2
Over 40%	18	50	15	19
Paraphyses:				
present	68	0	43	56
absent	32	0	57	44

found in 15% of epiphytic forms and 25% of terrestrial. There is a trend to lack of pneumatophore in terrestrial species, with 20% lacking this structure. In the epiphytes only 4% were lacking it.

Mature pneumatophores were frequently observed on the rhizome in areas of leaf primordia. In many instances as the petiole developed, the tissues of the pneumatophore appeared to fuse with those of the petiole. The function of the structure is unknown, although Troll (1933) believed that it was for aeration in areas of high metabolic rate, especially where aeration was restricted, such as croziers with heavy mucilage. This substance has not been found in *Elaphoglossum*, however.

Although Type C is the most common type of pneumatophore, at elevations above 2500 m there is a sharp increase in number of species without pneumotophores and with Type G (*Table IV*).

Laminar Scales.—The structure of scales and hairs on the frond varies from simple or capitate glandular hairs to peltate scales. The variation in structure found in plants from Costa Rica is similar to that found by Bell (1955, *fig. 8*) for plants from other areas of the world. The most common scale type was laminate, attached at the base with cordate or lobed basal wings (Bell, *fig. 8–7*). In only six species did scale types differ on the adaxial and abaxial surfaces: *E. auripilum* Christ, *E. aff. hirtum* (Swartz) C. Chr., *E. muscosum* (Swartz) Moore, *E. revolvens* (Kunze) C. Chr., *E. aff. tectum* (Humb. & Bonpl.) Moore, and *Lloyd 4220*. In *E. auripilum* and *E. aff. tectum* the more complex scale type was found on the adaxial surfaces.

Over half of the 70 species examined in detail possessed no scales at all on the adaxial surface. Of those with scales, 77% had a coverage of less than 10% and only 4% had a coverage of greater than 40% (*Table II*). Sixty percent of the terrestrial species and 50% of the epiphytic were glabrous. In most instances the trends

---

[a] Pneumatophore types: A. None. B. Lenticel line extending from the base of the phyllopodium into the petiole; no flange. C. Lenticel line present with slight flange near the base. D. No lenticel line; slight flange present at base of phyllopodium. E. No lenticel line; definite flange present. F. No lenticel line; enlarged flange. G. No lenticel line; club-shaped flange.

[b] Figures of the various types are from Bell (1955).

present on the adaxial surface were similar to those found on the abaxial surface. On the abaxial surface, however, scale density was greater, with about 18% of the species having over 40% coverage.

Elevation apparently has no profound effect on either scale type or density. From the data given in *Table III*, there appears to be only a slight trend toward more scaliness on the abaxial

TABLE III. NUMBER OF SPECIES OF EACH SCALE TYPE IN RELATION TO ELEVATION

	Scale type[a]						
Elevation	*A*	*B*	*C*	*D*	*E*	*Glabrous*	*% Glabrous*
Adaxial Surface							
0–1000 m	0	0	0	0	1	3	61[b]
1000–2500 m	1	5	8	1	4	17	47
Above 2500 m	0	3	5	2	3	15	54
Abaxial Surface							
0–1000 m	0	0	3	0	1	0	26[b]
1000–2500 m	1	4	18	2	5	7	19
Above 2500 m	0	2	14	4	5	3	10

[a] See Table II for scale types and references to illustrations in Bell, 1955.
[b] Based on 13 species, 4 of which were analyzed as to type.

surfaces at higher elevations. However, this trend appears to be reversed on the adaxial surface.

Paraphyses.—Copeland (1947, p. 119) stated that paraphyses are wanting in *Elaphoglossum*. However, recent studies by Anderson and Crosby (1966) indicate the presence of paraphyses in some Hawaiian species. A survey of fertile fronds in Costa Rican material indicates that 56% have paraphyses. In most cases the paraphyses are short, uniseriate, multicellular branches arising from the upper portion of the sporangial stalk near the base of the sporangium. In a few cases they arise from the receptacle

(*Lloyd 4268*) or from both the receptacle and the sporangial stalk (*Lloyd 4284*). They are usually glandular at maturity. Paraphyses occur in 68% of epiphytic species and only 43% of terrestrial (*Table II*).

TABLE IV. PERCENT OF SPECIES WITH CHARACTERISTICS IN RELATION TO ELEVATION

Character	0–1000 *m*	1000–2500 *m*	2500–*above*
Swelling Present	75	84	68
Jointed	75	90	79
Pneumatophore:			
Type A[a]	25	5	11
B	0	13	4
C	0	45	36
D	0	8	7
E	25	5	7
F	25	13	7
G	25	11	28
Paraphyses Present[b]	100	54	61
No. species investigated	4	38	28

[a] See Table II for description of types.
[b] Based on percent of taxa with fertile fronds.

Asexual Reproduction.—Vegetative reproduction is infrequent in most ferns and rare in *Elaphoglossum*. In the Costa Rican material it was found in only one species, *E. undulatum* (Willd.) Moore (*Lloyd 4177*). Plants of *E. undulatum* occur in very wet secondary forest near San Ramón and regularly produce asexual buds from the terminal portion of the midvein of the frond. This species was usually epiphytic, normally between 0.5 and 1 meter above ground level, with pendent fronds which frequently came in contact with the soil. Buds and new plantlets were observed on mature fronds, increasing in size as the parent fronds aged. As the parent fronds degenerate, the new plantlets formed terrestrial colonies at the base of the tree.

Other Sporangial Features.—Sporangia tend to arise in numerous, circular sori below the veins. As the fertile fronds mature, these sori merge together and become acrostichoid. The number of indurated annular cells of the sporangia vary from 10 to 15, with 12 being the most frequent. Chlorophyll is present in the sporangial stalk in about one-third of the species.

DISCUSSION

The most obvious trend found in this study in *Elaphoglossum* is toward the terrestrial habitat with increasing elevation. In lowland rain forest, 93% of the species were epiphytic. In highland wet forest (above 2500 m) only 50% of the species were epiphytic. This trend is frequent in other groups of plants, including Bryophyta, Bromeliaceae, and Orchidaceae. At lower elevations species are either terrestrial or epiphytic, but not both. At upper elevations, particularly in exposed habitats, this distinction breaks down. The cause of this phenomenon is only vaguely known. Wet cloud forest, with its somewhat stunted trees, has altered the terrestrial habitat and permits normally epiphytic species to grow. This may be due to increased humus, mosses, water and light. At lower elevations the available moisture in the soil is greater than that on the trees, but here other factors, such as lack of light or available substrate, must control plant distribution. There is little evidence to indicate whether the terrestrial habitat is less extreme than the epiphytic, although it is apparent that the former may provide the more suitable habitat during dry periods in those areas with a marked wet–dry climate. Terrestrial habitats also provide greater protection from drying winds. Some terrestrial habitats, especially those of disturbed areas along roadsides where there is no protective cover, appear to have more extreme conditions. Species of *Elaphoglossum* that occur in these habitats have coriaceous fronds, a feature that Lloyd (1965) found to be associated with xeric environments in *Polypodium*.

There are certain characters correlated with either epiphytic or terrestrial habitat. These are:

Epiphytic	*Terrestrial*
Non-jointed	Jointed
Non-swelling	Swelling
Type C pneumatophore	Type G pneumatophore
Pneumatophores present	Pneumatophores absent
Scaly	Glabrous
Type B, C, & E scales (adaxial surface)	Type C scales (adaxial surface)
Paraphysate	Non-paraphysate

The strongest of these trends is toward the absence of paraphyses in terrestrial plants. In addition, there is a slight increase in the frequency of paraphyses with higher elevations, although the number of terrestrial species also increases. If paraphyses evolved as protective structures against desiccation of young sporangia, epiphytic plants more exposed to changing conditions would be expected to show a higher frequency of presence. This might also be true of plants in more extreme situations at higher elevations.

Bell (1955) found a close association between the joint and the presence of pneumatophores, although he believed that they were probably independently controlled genetically. The function of the pneumatophore is unknown. The function of the joint may be as a mechanism for shedding leaves, as in *Oleandra*. Holttum (1966) believed that this was an adaptation to the epiphytic habit. However, in *Elaphoglossum*, terrestrial plants show a higher frequency with joints than do epiphytes. Species at higher elevations also possess this structure less frequently.

The trends in scaliness are of uncertain significance. Plants with both glabrous and densely scaly fronds occur side by side in many different habitats. Christ (1899) believed that species at higher elevations tended to have densely scaly fronds and those at lower elevations glabrous fronds. My results indicate that the adaxial surface of the frond is less densely scaly at higher elevations than at mid-elevations. However, on the abaxial surface

scale density increases with elevation. Over 50% of the species from elevations above 2500 m had glabrous fronds or fronds with less than ten percent of the surface covered by scales.

It is obvious from this study that the relationship between the characters investigated and the habitat is complex. The wide diversity in structure may be due to maintenance of much of the diversification through time since the origin of the genus in a stable, continuously tropical habitat (Bell, 1956), and in fact, there may be no correlation with habitat for many of the features I studied. Further studies are needed, however, before definite conclusions can be reached as to the evolution of the various features and their relationship to the environment.

Use of Characters for Taxonomic Purposes.—Many of the features elaborated in this study appear to be useful for taxonomic delineation of species. Of particular importance are scale type, pneumatophores, presence or absence of a joint and phyllopodium, and presence and type of paraphyses. Bell (1955) found that the scale types are constant in any one species. This may be true of the other features, although large numbers of individuals of each species have not been investigated. Nearly all 70 species can be distinguished using a combination of these characters.

ACKNOWLEDGEMENTS

Much of this work was done while I was involved in a course on the biology of tropical pteridophytes, sponsored by the Organization for Tropical Studies. I am indebted to that organization and to the University of Costa Rica for providing funds and facilities while in Costa Rica. I am also indebted to Drs. W. H. Wagner, Jr., J. T. Mickel, D. B. Lellinger, A. M. Evans, and C. V. Morton for their helpful criticisms and comments during the study. Specimen identification was done by Drs. Mickel and Lellinger.

LITERATURE CITED

ANDERSON, W. R. and M. R. CROSBY. 1966. A revision of the Hawaiian species of Elaphoglossum. Brittonia **18**: 380–397.

BELL, P. R. 1950. Studies in the genus Elaphoglossum Schott. I. Stelar structure in relation to habit. Ann. Bot., Lond. n.s. **14**: 545–555.

———. 1951a. Studies in the genus Elaphoglossum. II. The root and bud traces. Ann. Bot., Lond. n.s. **15**: 333–346.

———. 1951b. Studies in the genus Elaphoglossum. III. Anatomy of the rhizome and frond. Ann. Bot., Lond. n.s. **15**: 347–357.

———. 1955. Studies in the genus Elaphoglossum. IV. The morphological series in the genus and their phylogenetic interpretation. Ann. Bot., Lond. n.s. **19**: 173–199.

———. 1956. Studies in the genus Elaphoglossum. IV. Part Two. Ann. Bot., Lond. n.s. **20**: 69–88.

CHRIST, H. 1899. Monographie des genus Elaphoglossum. Denkschr. Schweiz. Naturforsch. Ges. **36**(1): 1–159.

COPELAND, E. B. 1947. Genera Filicum. Waltham, Mass.

HOLTTUM, R. E. 1966. Florae Malesianae Precursores XLIV. The fern genus Elaphoglossum in Malaysia, with descriptions of new species. Blumea **14**: 317–326.

LLOYD, R. M. 1965. Clinal patterns in frond anatomy of Polypodium. Madroño **18**: 65–74.

SCOTT, N. J. 1966. Ecologically important aspects of the climates of Costa Rica. Organization for Tropical Studies, Mimeo.

TROLL, W. 1933. Botanische Mitteilungen aus den Tropen. IX. Dryopteris sumatrana v.A.v.R., ein neuer Schleimfarn aus dem ostindischen Archipel. Flora (Jena) n.f. **28**: 329–337.

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News and Notes

FERN FORAY PARTICIPANTS should write for details to Miss Lois Carlson, Matthaei Botanical Garden, University of Michigan, Ann Arbor, Mich. 48105 if they have not already done so.

MRS. CHARLES BITTINGER, who was instrumental in developing the Fern Valley at the National Arboretum in Washington, D. C. during the 1950's, died in Washington on April 24 at the age of 95. She had been active in garden club activities in the Washington area for many years, and had received honors from the Garden Club of America. She was also interested in music and the other arts, and was a member of the Women Geographers, an arm of the Explorer's Club. She described the establishment and growth of the Fern Valley in a well illustrated article several years ago (Amer. Fern J. **51**: 161–173. 1961).

Recent Fern Literature

THE VICTORIAN FERN CRAZE, by D. E. Allen. Hutchinson and Co., Ltd. 178–202 Great Portland Street, London W. 1, England. $3.00 postpaid. 83 pp. illus. 1969.—Today's growers of ferns are, by and large, a sensible lot, who grow their ferns in plastic pots on window sills and who even may have some scientific interests that run to the detection of hybrid ferns or the discovery of the life cycle of some particularly interesting species. A century ago. however, such was not the case. Gardeners, particularly in Great Britain, were seized with a pteridomania that rivaled the tulip mania which had seized Holland some time before. Hybridization of ferns being difficult and full of chance, the fern fanciers of Victorian England combed the wilds of their island in search of sports and fancy varieties of their native ferns. In many cases, they decimated natural populations. They searched their gardens and greenhouses for specimens varying in texture, dissection, and habit, all with an eye to presenting a striking novelty at the next garden show. The principal stimulus to this frantic activity was the popularization of Wardian cases which, being closely glazed, developed a high humidity suitable to the growth of ferns. Even filmy ferns could be maintained in an average home in a Wardian case. Unlike the simple terraria or bell-jars of today, the closely glazed cases of a century ago were ornamented with considerable quantities of intricately carved woodwork. They formed a large and very fashionable part of the furnishings in the best homes of the time. The discoveries of Dr. Ward and others, the production of books on ferns by both amateur and professional botanists, the pteridomania itself, and the eventual slackening of interest in fancy ferns are all admirably told by Mr. Allen in this delightful book.—D. B. L.

WELSH FERNS, CLUBMOSSES, QUILLWORTS, AND HORSETAILS, A DESCRIPTIVE HANDBOOK. By H. A. Hyde and A. E. Wade, ed. 5, by S. G. Harrison. xii + 178 pp. illus. 1969.—Despite the title of "Welsh Ferns" this useful handbook treats all the native

ferns of the British Isles. This new edition is thus the most recent treatment of the ferns of this area. Mr. Harrison has taken account of current work on hybrids, chromosome numbers, and nomenclature, and has added a completely new section on the fern allies, which were not discussed in the previous editions. This new edition is thus useful even for those having an earlier edition. A review of this new edition was written by C. Jermy (British Fern Gazette **10:** 105, 106. 1969), in which a few nomenclatural changes were suggested. This new edition not only divides the Polypodiaceae into numerous smaller families but even into several orders. It may be mentioned that two of these family names are incorrect, Gymnogrammaceae and Aspidiaceae, since they are based on illegitimate generic names. I want to mention only one nomenclatural point, a rather troublesome one. So long as *Polypodium cambricum* L. is considered as a variety of *P. vulgare* L. there is no problem. However, when *P. vulgare* is split into three species, as here, with different chromosome numbers, the matter of priority enters. True *P. vulgare* is a tetraploid, and the diploid is now called *P. australe* Fée (1852). Miss Shivas has found that *P. cambricum* is also diploid, and so in this work it is placed as *Polypodium australe* 'Cambricum'. This form would seem to indicate that it is a cultivar, but it is not, for it was described from wild material and is still found in the wild. The nomenclatural point is that *P. cambricum* L., dating from 1753, antedates *P. australe* Fée by a hundred years and is thus the correct name for the species. The reason that it has not been adopted is probably because it represents an abnormally cut form. One might argue that Art. 71 of the Code could be applied and the epithet *cambricum* rejected as being based on a monstrosity, which means that it can not be used at all, certainly not as a variety of *P. australe*. However, in my opinion, Art. 71 was not intended to make names of this sort illegitimate; that would mean that no abnormal forms could ever be named, for these names would automatically be illegitimate and rejected. A solution to this dilemma in this particular case is to regard *P. cambricum* not as a variety of anything but as a possible hybrid *P.* × *cambricum*. I do not know if this has ever

been suggested, but it is comp'etely reasonable and probably can not be disproved. The plants do have "hybrid irregularity" and are completely sterile. Since it is a diploid, one of the parents would be *P. australe*; it is impossible to say what the other parent might be, since there is no other diploid *Polypodium* in the area or indeed in all of Europe. Still, this assumption would be sufficient to maintain the name and *P. australe* also and therefore it should probably be made in order to avoid a confusing and somewhat misleading change of name for a common species.- C.V.M.

FERN HYBRIDIZING AT THE UNIVERSITY OF LEEDS, by John D. Lovis. Reprinted from the British Fern Gazette, British Museum (Natural History), London S. W. 7, England. $0.50 postpaid. 8 pp. 1968.—Dr. Lovis has written an interesting and detailed review of the hybridization techniques that have been used so successfully by pteridologists trained at the University of Leeds. He gives some useful methods for gathering and sowing spores, preventing contamination of cultures by unwanted spores and various extraneous organisms, for transplanting minute prothallia, and for producing cultures ready for hybridization at the proper time. An exacting but rather foolproof method of hybridizing is also presented.—D. B. L.

KARYOLOGICAL STUDIES ON ASPLENIACEAE I. KARYOTYPES OF THREE SPECIES IN ASPLENIUM, by S. Tatuno and S. Kawakami. Bot. Mag. Tokyo **82**: 436–444. 1969.—The three species studied, *Asplenium incisum* Thunb., *A. oligophlebium* Baker, and *A. tripteropus* Nakai, are all normal diploids, with $2n = 72$. The authors have studied the chromosome morphology and can divide the chromosomes into six types, each with two subtypes. From these observations they conclude that the true base number for *Asplenium* is 12, and that these "diploid" species are really hexaploids. I believe that this is the first demonstration in support of the belief that modern ferns with high chromosome numbers are really polyploids of ancient ancestors with low numbers. - C.V.M.

THE PTERIDOPHYTA OF TAIWAN–5. HYMENOPHYLLACEAE: TRICHOMANES, by Charles E. DeVol. Taiwania **14:** 89–132., *t. 1-14.* 1968.—DeVol has continued his valuable series of papers on the ferns of Taiwan with an extensive study of *Trichomanes*, in which a special emphasis is given in the descriptions and illustrations to the cellular structure of the blades, very likely an important character in this genus and one that is insufficiently known. Van den Bosch, the monographer of the genus, paid attention to this character, sometimes to the relative neglect of other possibly more usable ones, but he has been little followed. Although DeVol uses the name *Trichomanes* in his title and in the title to the key to the species, he actually does not recognize the genus in the inclusive sense but instead recognizes all of Copeland's small segregates, indicating that they are "well known and easily recognized groups," a conclusion that I am unable to agree with. He also does not accept my typification of *Trichomanes* on *T. scandens* L., without disputing the argument but for the reason that this species belongs to a small section that has fronds with ciliate margins and comes from the West Indies, but the size of a group that the type species belongs to is strictly irrelevant to its typification, as are also its geographic provenience and characters. In my discussion of the typification of *Trichomanes* (Contr. U. S. Nat. Herb. **38:** 177. 1968) I mentioned that Dr. Holttum had questioned Copeland's typification without making any change himself, but I overlooked a previous paper by Holttum (Gard. Bull. Str. Settl. **12:** 304. 1949) in which Holttum *did* go into the matter and came up with the same conclusion as I, namely that John Smith's selection of *T. scandens* as lectotype in 1875 can not be altered. That really should not cause any inconvenience, because this was the usual view up until the time of Copeland's 1938 paper.—C.V.M.

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American Fern Journal

Vol. 60 July–September, 1970 No. 3

Stelar Anatomy of Six Species of Lycopodium[1]

Sr. Frances M. Cardillo

A review of the literature indicates that only limited studies have been made on the stelar patterns of the club mosses and that little has been attempted in comparative investigations. Holloway (1916) found that the vascular cylinders of New Zealand lycopods exhibited specific stelar patterns. He thought that the cortical sclerenchyma affected stelar arrangement and that the presence of this tissue could be responsible for imparting rigidity and lateral pressures to the stele. This rigidity and lateral pressure support the stele in such a way that the xylem elements become more definitely arranged in groups or bands.

Later, Holloway (1919) concluded that there were two basic patterns in which the xylem elements were arranged; these patterns also appeared to be associated with the leaf trace system: (*i*) the mixed type in which the leaf trace system extends beyond the cauline vascular cylinder and (*ii*) the banded or parallel type in which the vascular cylinder becomes strongly developed and the leaf traces affix themselves to it. He interpreted the banded type as a specialization of a radial pattern that was caused by a restriction on the stem in monopodial branching. Holloway also associated stelar patterns with prothallus type: short-lived prothalli were characteristic of the mixed type of vascular cylinder and long-lived prothalli of the banded pattern. He noted that these differences were exhibited in all the species of *Lycopodium*

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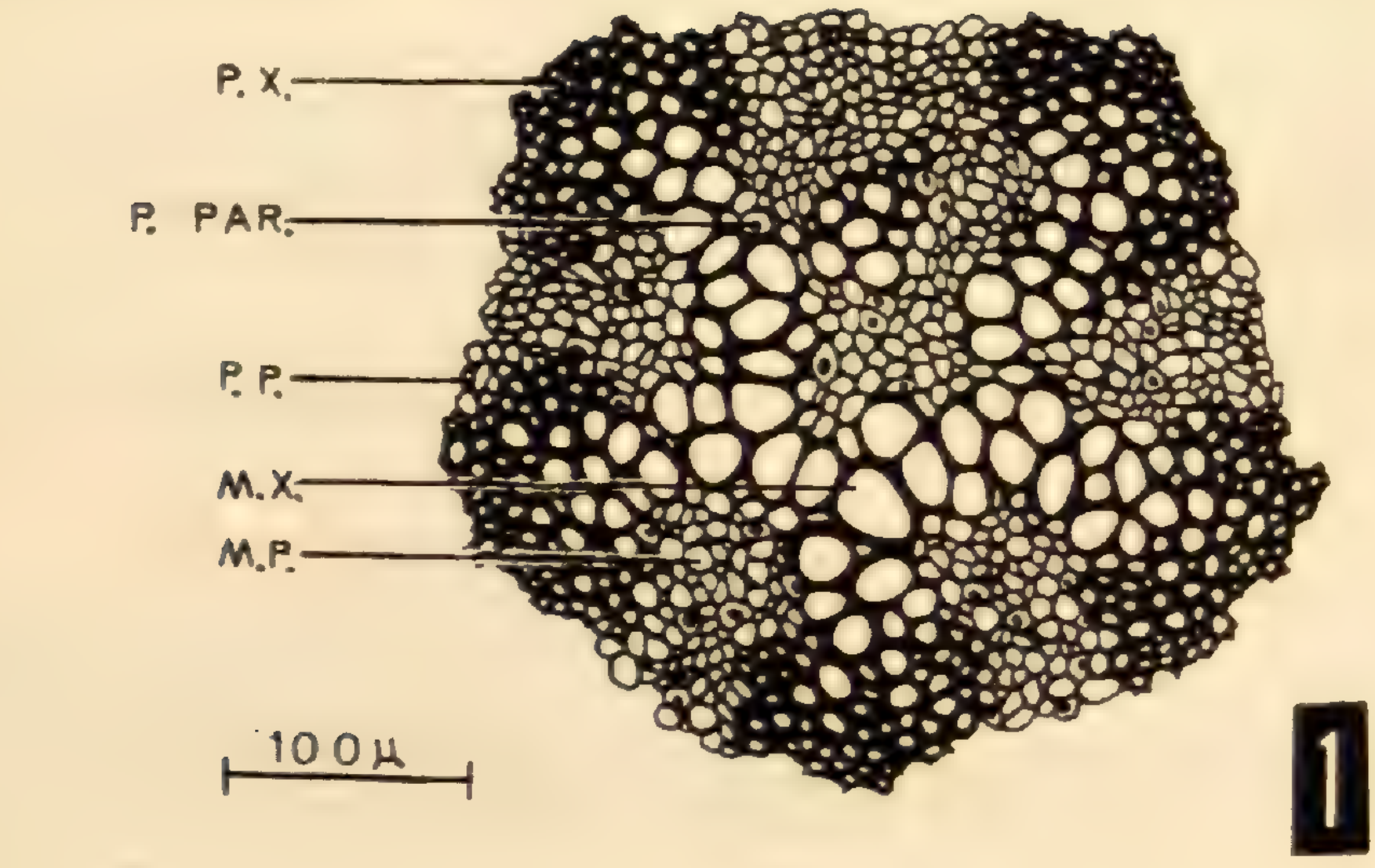
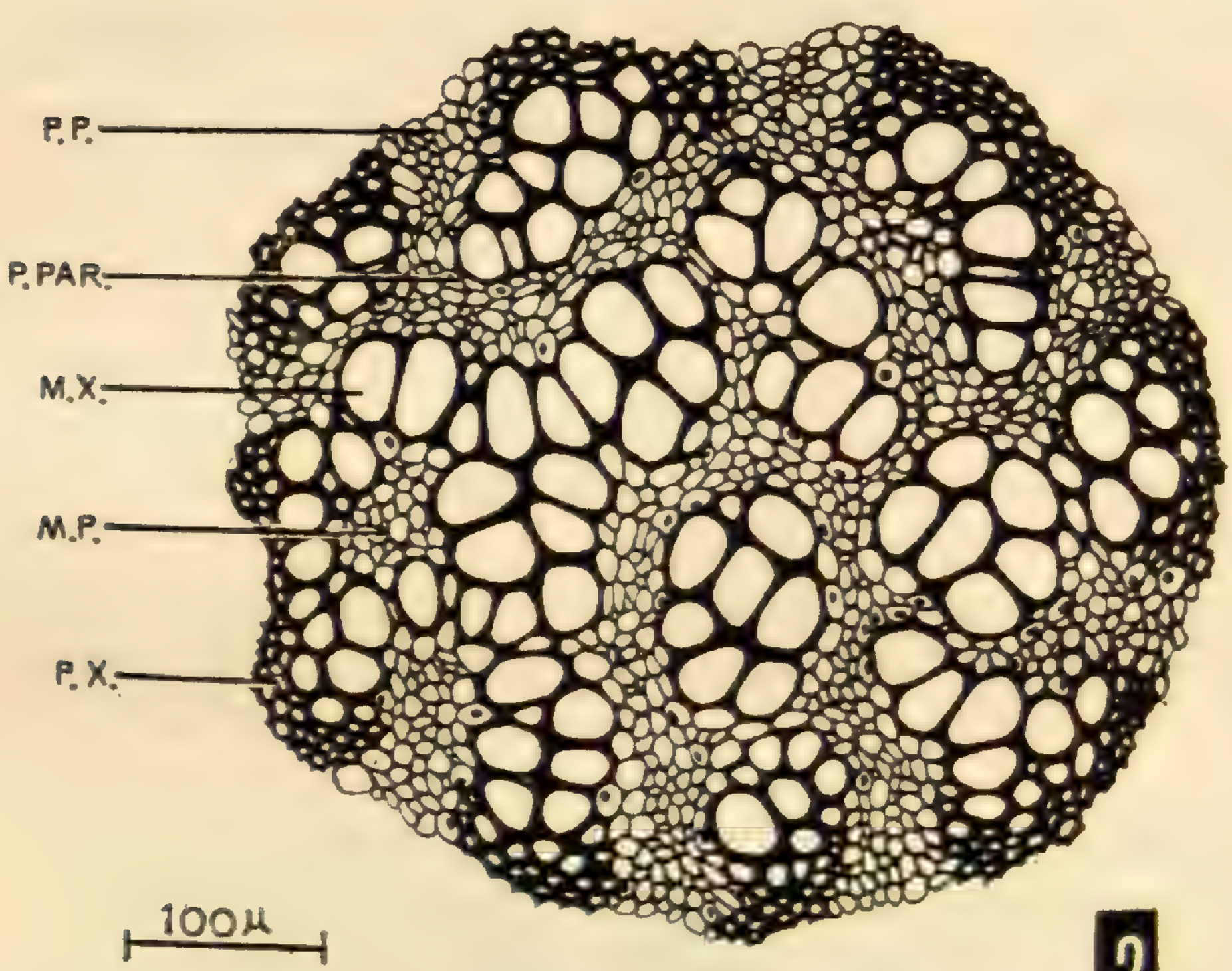
[1] This study represents a portion of a doctoral dissertation submitted to the Graduate School of St. Bonaventure University, St. Bonaventure, N. Y. Appreciation is extended to Dr. Alfred F. Finocchio for advice during the course of the research.

Volume 60, No. 2, of the Journal, pp. 49–88, was issued July 3, 1970.





Tracings of Composite Photographs of the Vascular Cylinders of Lycopodium lucidulum and L. annotinum. The abbreviations are: m.p. = metaphloem, m.x. = metaxylem, p.par. = phloem parenchyma, p.p. = protophloem, and p.x. = protoxylem.

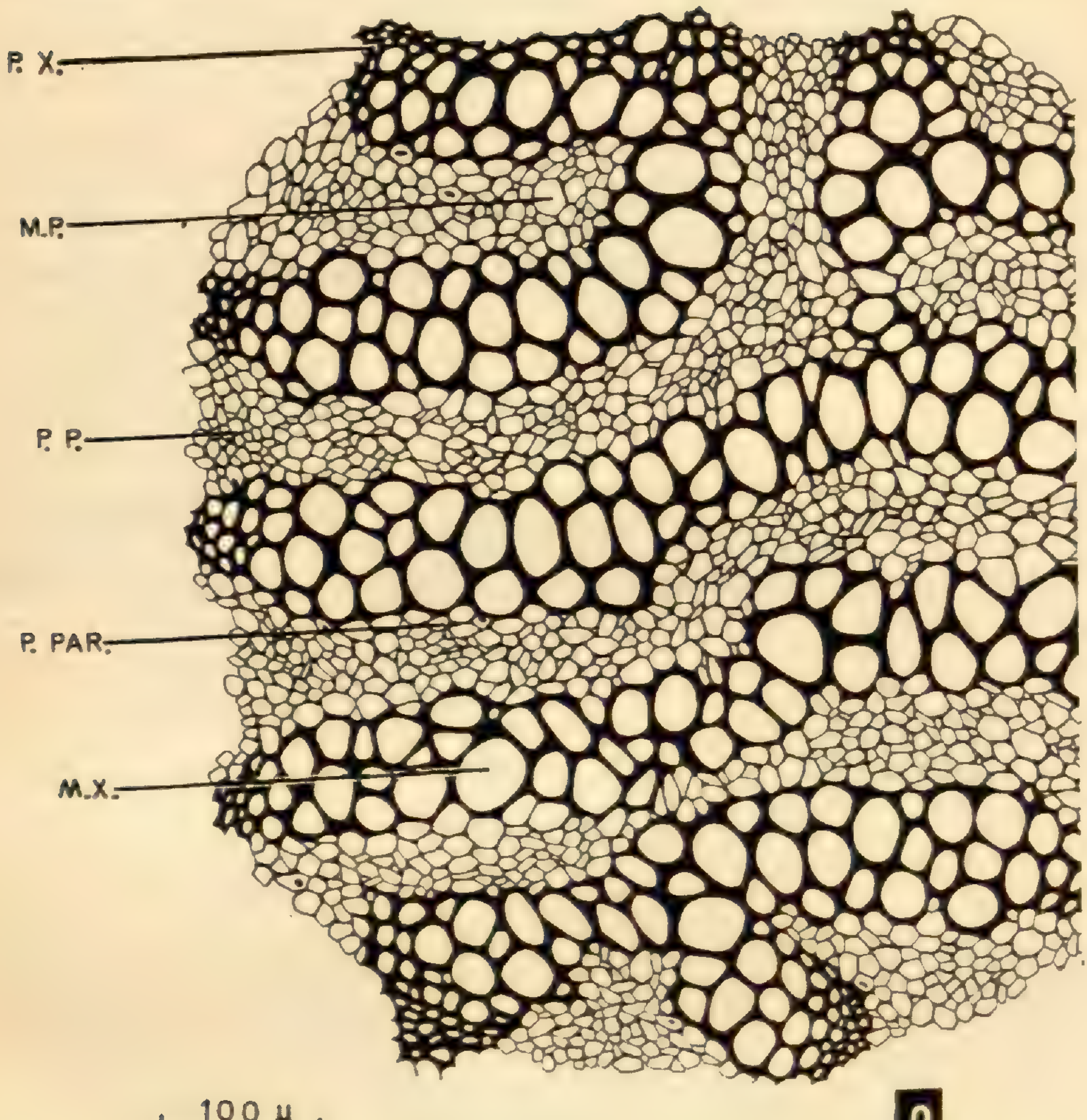
which he studied, regardless of whether their growth habit was vertical or horizontal.

This study was undertaken to examine additional species of *Lycopodium*. A comparative investigation of the transverse sections of stems of six species found in the northeastern United States revealed similar stelar patterns in addition to several other observations. The species collected in southern Cattaraugus County, New York (Cardillo, 1967) were: *Lycopodium lucidulum* Michx., *L. flabelliforme* (Fernald) Blanchard, *L. tristachyum* Pursh, *L. clavatum* L., *L. annotinum* L. var. *annotinum*, and *L. obscurum* L.

First, stem sections of the same species taken at various distances from the apex were compared. These showed slight differences which could be attributed to age (Bower, 1935). It was evident, however, that such differences did not alter the basic stelar pattern. For comparative study transverse sections were taken from subapical regions of the main stems where maturation was known to have occurred. This would rule out the minimal differences in stelar patterns attributed to age.

Tissues were killed and fixed by freeze substitution and dehydrated in cold absolute ethyl alcohol (Jensen, 1962). Iodine–potassium iodide served to detect phloem and phloem parenchyma; phloroglucinol-HCl was used to detect xylem (Roberts & Herty, 1934). Since this investigation dealt with a comparative study of mature stelar patterns and the cortical sclerenchyma was not under study except for its effect on supporting vascular tissue in the living plant, the cortical material was removed just before killing and fixing. Thus, steles were processed instead of entire stem sections. This facilitated histological procedures and gave more accurate results. Fisher Tissuemat (melting pt. 56.5° C) was used for embedding. Sections were stained with basic fuchsin and counterstained with fast green so that a cellular inclusion giving a positive Feulgen reaction could then be identified as a nucleus (Jensen, 1962).

Since cell diameters ranged from 3 μ to 50 μ, it was necessary to examine each transverse section at a magnification of 430 × or higher. In order to make a comparative study of cellular size and



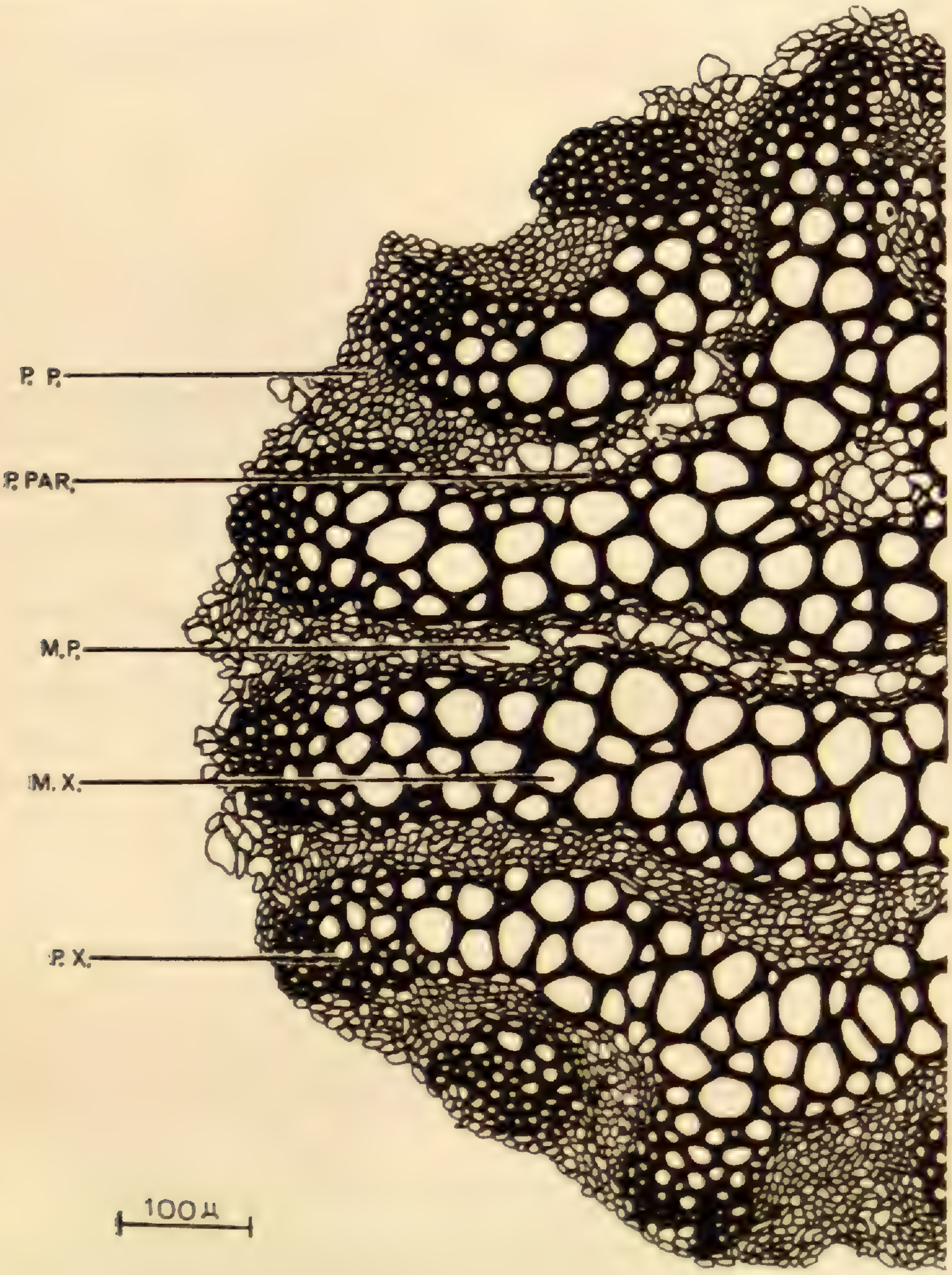
3

Tracing of a Composite Photograph of the Vascular Cylinder of Lycopodium obscurum. For abbreviations see *Plate* 9.

shape, illustrations of these sections were made. *Figs. 1–6* are accurate drawings that were traced from composite photographs of each stele. Such composite photographs were compiled so that the details of very small cells would not be lost.

Differences not previously reported were revealed in this study. The results agree with Wardlaw's (1965) statement that differences of detail are only exposed in a comparative study of species in the same genus. *Table I* gives a comparative description of these details. These results also substantiate Bower's (1935) description of the stele of *Lycopodium* in that the xylem tracts are not distinct from one another for any great distance along the stem. The xylem structure anastomoses and there is a continuous invagination of the phloem and conjunctive parenchyma. In some areas of the plant, the stele with respect to stem diameter enlarges, but a relatively constant surface proportion of living tissue to adjoining dead tracheids is always maintained.

Very few nuclei were detected in any one section. Macerated preparations and longitudinal sections of the stele showed sieve cells and phloem parenchyma cells of unusual length. These cells also exhibit long and considerably vacuolated nuclei. Whether or not cells containing these nuclei were protophloem, phloem parenchyma, or pericycle could not be determined. No attempt was made to identify these cells in macerated preparations; in longitudinal sections the only way to identify the cell type is by position in respect to the xylem and the sieve areas located on the walls of the phloem and protophloem. Cells of the central portion of each phloem band were enucleate, but nuclei were detected in cells on the periphery of these bands. In longitudinal section, these cells of the central portion appear thin walled and are marked with sieve areas. Cells of the protophloem located at the periphery of the stele and intermitent with protoxylem bear similar markings. These cells contain nuclei and some also contain abundant cytoplasmic inclusions which were detected in sections stained with Conant's Quadruple Stain. Results with the periodic acid–Schiff reaction also show cytoplasmic inclusions, but these tissues produce a negative Feulgen reaction; evidently the cellular contents



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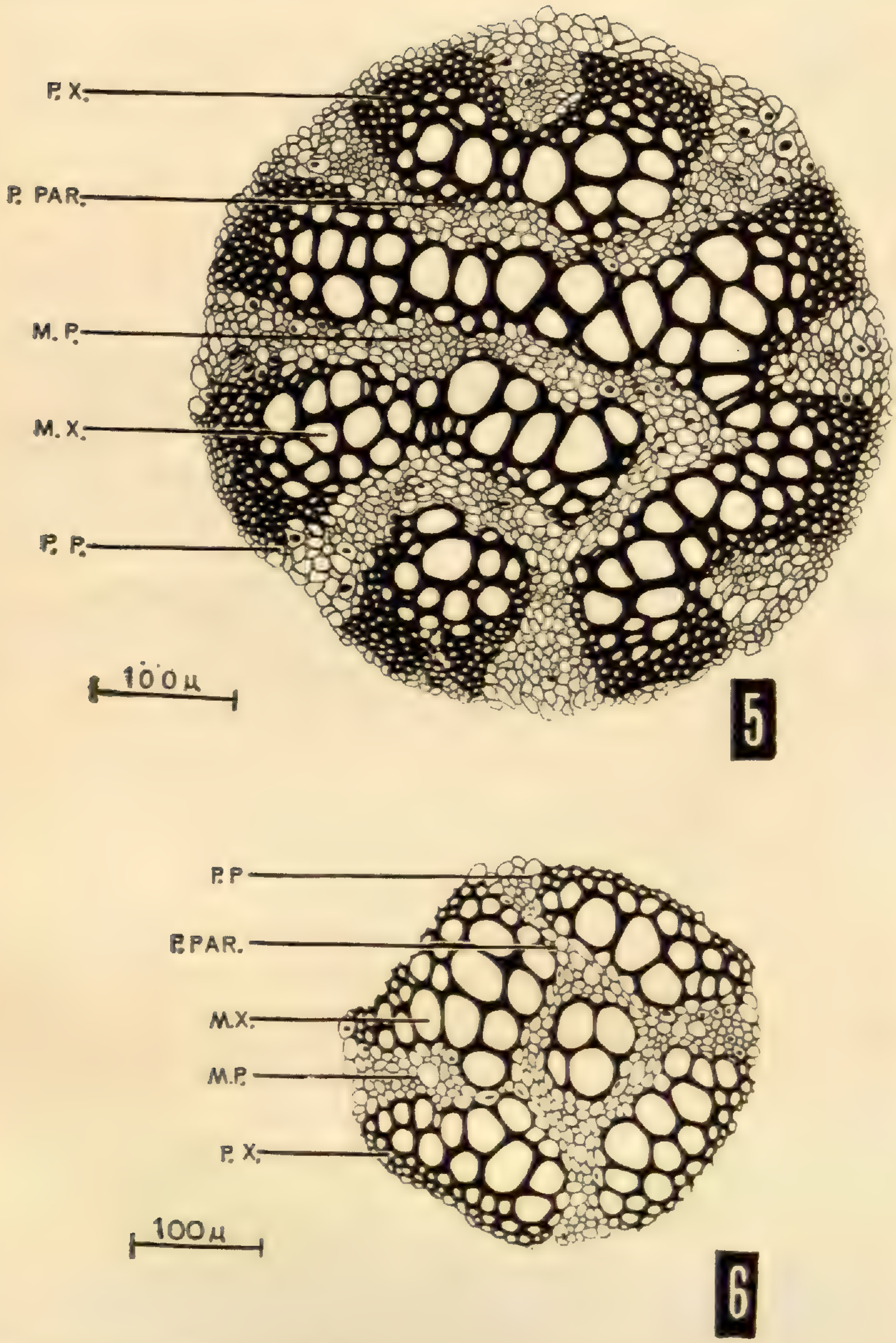
Tracing of a Composite Photograph of the Vascular Cylinder of Lycopodium flabelliforme. For abbreviations see *Plate* 9.

TABLE I. COMPARISON OF STELAR FEATURES OF SPECIES OF LYCOPODIUM

Species	*Approx. size of stele*	*Pattern*	*Range in tracheid diameters*[1] *Protoxylem*	*Metaxylem*	*Description of nontracheary elements*
L. lucidulum, *Fig. 1*	350 μ	radial	5–8 μ	7–30 μ	small cells all similar in size
L. annotinum var. annotinum, *Fig. 2*	500 μ	banded	4–8 μ	10–40 μ	small cells; differ slightly in size
L. obscurum, *Fig. 3*	700 μ	banded	3–7 μ	7–30 μ	slightly larger cells; slight differentiation in size
L. flabelliforme, *Fig. 4*	950 μ	banded	4–9 μ	12–56 μ	marked differentiation in size of cells in central bands
L. clavatum, *Fig. 5*	525 μ	banded	3–8 μ	10–50 μ	noticeable differentiation in cell size
L. tristachyum, *Fig. 6*	325 μ	banded	6–8 μ	10–45 μ	slight differentiation in cell size

[1] Data represent a statistical analysis (Cardillo, 1966).



Tracings of Composite Photographs of the Vascular Cylinders of Lycopodium clavatum and L. tristachyum. For abbreviations see *Plate* 9.

are not nuclear material.

This investigation shows that in addition to the basic stelar patterns known to exist in the genus *Lycopodium*, as described by Holloway (1919), there is a difference in size, shape and orientation of the xylem and phloem tissue in the six species herein studied. The differences are characteristic of each species, and in anatomical studies they could be used as criteria for species identification.

LITERATURE CITED

BOWER, F. O. 1935. Primitive land plants. Macmillan, London.

CARDILLO, F. M. 1966. The comparative anatomy of six north-eastern species of Lycopodium. Ph.D. Dissertation, St. Bonaventure Univ., St. Bonaventure, N. Y.

———. 1967. The ecology and distribution of the genus Lycopodium in southern Cattaraugus County, New York. Science Studies **24**:35–43.

HOLLOWAY, J. E. 1916. Studies in the New Zealand species of the genus Lycopodium. Part I. Trans. New Zealand Inst. **48**:253–303.

———. 1919. Studies in the New Zealand species of the genus Lycopodium. Part III. Plasticity of the species. Trans. New Zealand Inst. **51**:161–216.

JENSEN, W. A. 1962. Botanical histochemistry. W. H. Freeman, San Francisco.

ROBERTS, E. A. and S. D. HERTY. 1934. Lycopodium complanatum var. flabelliforme Fernald: its anatomy and methods of vegetative propagation. Amer. J. Bot. **21**:688–697.

WARDLAW, C. W. 1965. Organization and evolution in plants. Longmans, Green, London.

WILCE, J. H. 1965. Section Complanata of the genus Lycopodium. Nova Hedwigia Beih. **19**:1–233.

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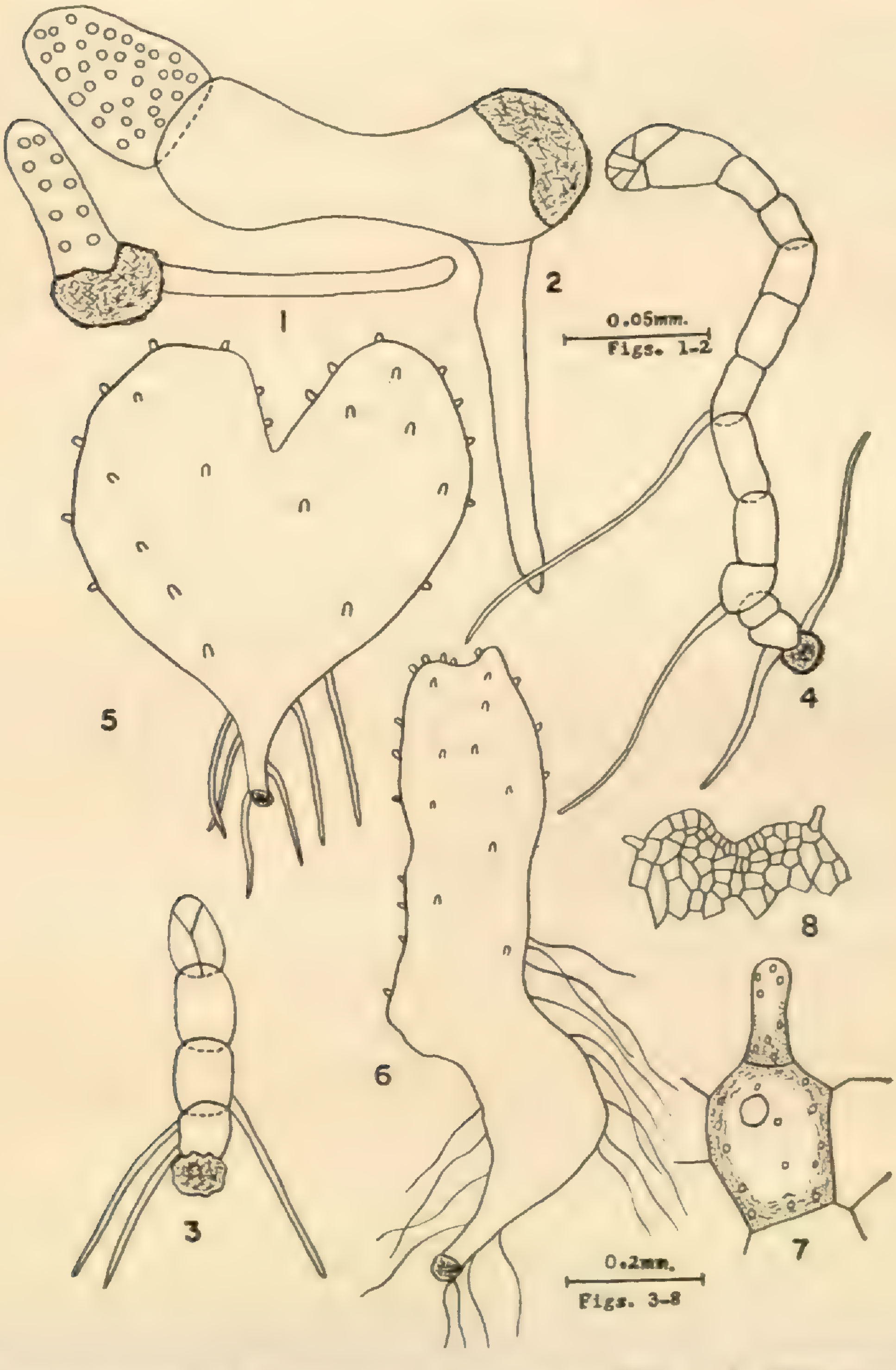
A Note on the Gametophytes of Cystopteris tenuisecta

S. S. BIR

Taxonomically the genus *Cystopteris* Bernh. was divided into two subgenera, *Cystopteris* and *Acystopteris*, by Blasdell (1963). Gametophytes of several members of subg. *Cystopteris*, such as *C. douglasii*, *C. protrusa*, *C. diaphana*, *C. bulbifera*, and *C. fragilis* (Blasdell, 1963; Kaur, 1963; Bir & Trikha, 1970), have been studied, but up until now no observations have been made on the gametophytes of members of subg. *Acystopteris*, to which the Asiatic species *C. tenuisecta* (Blume) Mett. belongs. Furthermore, this species has also been referred to *Cornopteris* by Tardieu-Blot (1958). Therefore, the present study was made to find out the relationship of *C. tenuisecta* to the other members of the genus and also to see if it really belongs to *Cystopteris* or not.

Cystopteris tenuisecta grows luxuriantly along open roadsides at Tiger Hill (alt. 2,400 m), Darjeeling (Eastern Himalayas). Both tetraploid sexual ($n = 84$) and triploid hybrid ($2n = 126$) individuals are abundant (Bir, 1961). The present study concerns only spores collected from tetraploid plants because the spores of the triploid did not germinate even after several trials. Gametophytes were raised by sowing the spores on full strength as well as on half-strength Knop's Solution. These were transferred to sterilized garden soil in pots when they were just expanded.

Freshly collected spores take about five or six weeks to germinate. Early stages of germination are very like those described earlier for other leptosporangiate ferns, such as *Hypodematium crenatum* (Loyal, 1960) and *Diplazium* (*Athyrium*) *esculentum* (Mehra, 1949; Nayar, 1960). On germination the exine ruptures irregularly near the central region of the spore, and a green germ filament emerges, followed by the first rhizoid. Sometimes after exine rupture the rhizoid emerges before the germ filament (*Figs. 1, 2*). When the germ filament becomes 4–6-celled, an apical cell is cut off by formation of two oblique walls in the terminal



Gametophytes of Cystopteris tenuisecta. Figs. 1–4. Filamentous stage. Fig. 5. Mature prothallus. Fig. 6. Prothallus in crowded culture. Fig. 7. Marginal papillate hair. Fig. 8. Prothallus margin.

cell (*Fig. 3*). In crowded cultures much elongated filaments are produced before an apical cell is organized (*Fig. 4*). Lateral expansion of the prothallus takes place subsequently by longitudinal division in the penultimate cells of the germ filament and by successive lateral divisions of the apical cell on both of its sides. These divisions give rise to a spathulate prothallus. The apical cell is soon replaced by an apical meristem, and this results in formation of a typical, cordate prothallus (*Fig. 5*) with an apical notch, except in those cases where the cultures are crowded (*Fig. 6*). Usually the cordate condition is attained in about three months.

The mature gametophytes resemble closely those of other higher leptosporangiate ferns. The central cushion is two or three cells thick. The margin is smooth. Marginal hairs start developing after the apical meristem is established and the prothallus becomes notched (*Fig. 8*). After this, superficial hairs develop generally on the prothallus surfaces. The hairs are unicellular, papillate, chlorophyllous, and non-glandular (*Fig. 7*). The sex organs appear when the gametophytes are about four months old, and their development is of the usual type.

The gametophytes of *C. tenuisecta* resemble those of *C. fragilis* (Kaur, 1963) and *C. douglasii* (Blasdell, 1963) in having a smooth margin and short hairs that appear late in gametophyte development. The gametophytes differ from those of *C. diaphana*, which have irregular margins at maturity and longer hairs that appear soon after the cell plate stage is initiated. The marginal, non-glandular hairs on the prothallus of *C. tenuisecta* are similar to those on the prothalli of *Diplaziopsis javanica* (Bir, 1970), *Athyrium japonicum*, *A. thelypterioides* (unpubl. data), and *Hypodematium crenatum* (Loyal, 1960). On the basis of gametophyte characters, *C. tenuisecta* is correctly placed in *Cystopteris* subg. *Acystopteris*, not in *Cornopteris*. Furthermore, *Cystopteris* is closely allied to the Athyrioid ferns that have close affinities to the Dryopteroid ferns.

LITERATURE CITED

BIR, S. S. 1961. *In* P. N. Mehra, Chromosome numbers in Himalayan ferns. Res. Bull. Panjab Univ., n.s. Sci. **12**:139–169.

———————. 1970. Observations on the morphology and anatomy of Diplaziopsis javanica (Bl.) C. Chr. Plant Sci. **1**:(in press).
———————, and C. K. TRIKHA. 1970. Morphological observations on genus Cystopteris Bernhardi. Nat. Acad. Sci. India. (in press).
BLASDELL, R. F. 1963. A monographic study of the fern genus Cystopteris. Mem. Torrey Bot. Club **21**(4):1–102.
KAUR, S. 1963. The gametophyte of Cystopteris fragilis. Proc. Indian Acad. Sci. **58**:148–152.
LOYAL, D. S. 1960. Some observations on the gametophytes of Hypodematium crenatum (Forsk.) Kuhn with a note on the phyletic affinities of the genus. J. Indian Bot. Soc. **39**:133–139.
MEHRA, P. N. 1949. Observations on the prothallus of Diplazium esculentum. J. Indian Bot. Soc. **28**:1–8.
NAYAR, B. K. 1960. The gametophyte and young sporophyte of Athyrium esculentum. Amer. Fern J. **50**:194–203.
TARDIEU-BLOT, M.-L. 1958. Validation of some new combinations. Amer. Fern J. **48**:31–34.

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The Lectotype of Polypodium leptophyllum L.

C. V. MORTON

Anogramma leptophylla (L.) Link (Fil. Sp. 137. 1841) is a rather common and widespread fern occurring in both the Old and New Worlds. It is based on *Polypodium leptophyllum* L. (Sp. Pl. 1092. 1753). So far as I know, no one attempted to pick out a lectotype for this species until Pichi-Sermolli (Webbia **21**: 497–502. 1966). However, I am unable to agree with the lectotype chosen or the method of selection.

The original publication is as follows:

leptophyllum 46. Polypodium? frondibus bipinnatis: sterilibus brevissimis; pinnis cuneiformibus lobatis. *Magn. monsp.* 5. *t.* 5.
Adiantum minimum, folio vario. *Magn. monsp.* 5, *t.* 5.
Adiantum filicinum leptophyllum elatius hispanicum. *Barr. rar.* 1270 *t. 431, opt.*
Habitat in Hispania, Lusitania, Galloprovincia.

Pichi-Sermolli wrote: "Linné gives Magnol's and Barrelier's phrase names and adds no original description of the species, as he

does for the new species such as *Polypodium varium* (p. 1090), *Polypodium marginale* (p. 1091), etc. Thus we are entitled to believe that Linné did not intend to introduce a new species, but accepted the basic concept of the species as established by Magnol and Barrelier. Consequently in selecting the lectotype, we have to take into consideration the plants described by these authors. However, it is worth mentioning that Linné notes that Barrelier's plate is 'opt.,' this means that he knew the species, probably through the specimen kept in the Linnean herbarium." Later he wrote: "In conclusion, *Anogramma leptophylla* cannot be typified on the specimen of the Linnean herbarium although present in it before 1753, since Linné did not describe the species at all, but clearly accepted the basic concept of the species as established by Magnol and Barrelier."

These remarks show a basic misunderstanding of the process of lectotypification of Linnean species as established by generations of workers and brought together by Stearn in his preface to the reprint of the "Species Plantarum." Pichi-Sermolli's idea that only a few of the species described in the "Species Plantarum" were new and that the others are to be typified on the basis of the literature reference cited is contrary to the Code. Botanical nomenclature begins with 1753 and *all* of Linnaeus' species are considered as new as of that date. Their lectotypification goes forward and depends on the work of later authors and does not go backward into pre-Linnaean literature necessarily. There is a general, if tacit, agreement that Linnaean species ought to be lectotypified on the specimens in the Linnean Herbarium whenever possible, that is, when there is reason to believe that a specimen was in the herbarium in 1753 and when it agrees with the diagnosis.

In the case of *Polypodium leptophyllum* L. there *is* a specimen in the Linnean Herbarium in London, under the number 1251.56. It bears the name *Polypodium heterophyllum* in Linnaeus hand and the number 46. As Pichi-Sermolli remarks, it is clear that Linnaeus first called this *P. heterophyllum* and altered the name in the publication to *P. leptophyllum* because he found that he had already applied the name *P. heterophyllum* to another species. The num-

ber "46" shows that this is indeed the species described as *P. leptophyllum*.

Pichi-Sermolli has chosen as lectotype *Tournefort 5337* in the Paris herbarium. Barrelier's herbarium was destroyed by fire, and so no specimen by him can be lectotype. This leaves Magnol (1697), who indicated that he had been given his specimen by Tournefort. No Magnol herbarium is known, and therefore Pichi-Sermolli goes back to the Tournefort Herbarium, where the plant now known as *Anogramma leptophylla* is represented by sheet 5337, which is therefore designated as lectotype. But there is really no proof that this specimen has anything to do with the species—it was not cited by Linnaeus, it was not seen by Linnaeus, and in fact Linnaeus did not mention Tournefort at all; and there is no certainty at all that the plant that Tournefort gave to Magnol was really the same as this sheet in the Tournefort Herbarium. Therefore, *Tournefort 5337* as a lectotype is impossible, especially when there is a perfectly good specimen in the Linnean Herbarium to be the obvious lectotype. Therefore, I propose the sheet 1251.56 in the Linnean Herbarium as lectotype of *Polypodium leptophyllum* L. and reject *Tournefort 5337*.

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Taxonomic Notes on Ferns, IV

C. V. MORTON

In the previous numbers of this series of casual notes on ferns, I published on *Athyrium lilloi* (Amer. Fern J. **50:** 275, 276. 1960), on *Thelypteris* sect. *Glaphyropteris*, *Blechnum penna-marina*, and *Asplenium varians* (Amer. Fern J. **51:** 37–39. 1961), and on *Anopteris hexagona* and *Elaphoglossum denudatum* (Amer. Fern J. **52:** 148–150. 1962). The present paper discusses four species of Chile, Argentina, and subantarctic South America.

LOMARIA MICROPHYLLA Goldm. Nov. Act. Acad. Caes. Leop. Carol. **16,** Suppl. 1: 460. 1843 = *Blechnum* **microphyllum** (Goldm.) Morton, *comb. nov.*

Lomaria australis Kunze, Linnaea 9: 57. 1834. Type: "Crescit in Chil. austr. Andibus ad Antuco, Lect. 1828," *Poeppig*. The holotype in the Kunze Herbarium was destroyed in Leipzig during the war. An undoubted isotype in the herbarium in Berlin-Dahlem, marked in Kunze's hand as "*Lomaria australis* mihi," is here designated lectotype (Morton photograph 10182). This photograph shows that *L. australis* is not a synonym of *Blechnum penna-marina* (Poir.) Kuhn, as indicated in the "Index Filicum," but is the same as the species later described as *Lomaria germainii* Hook. The epithet "*australis*," although the oldest for this species, may not be used in *Blechnum* because of the existence of *B. australe* L. (1767).

Lomaria gayana Rémy & Fée in Gay, Hist. Fis. Pol. Chile Bot. **6:** 481. 1853. Type: "Cordilleras de Talcaregue, provincia de Colchagua," Chile, *Gay*.

Blechnum poeppigianum Sturm, Enum. Pl. Crypt. Vasc. Chil. 26. 1859. Based on *Lomaria australis* Kunze, *non Blechnum australe* L.

Blechnum gayanum (Rémy & Fée) Sturm, Enum. Pl. Crypt. Vasc. Chil. 24. 1859.

Lomaria germainii Hook. Sp. Fil. **3:** 32, *pl. 152*. 1860. Syntypes: Cerro de la Campaña de Quillota, *Germain* and Antuco, Chile, *Poeppig*. Looser chose the Germain collection as lectotype.

Blechnum germainii (Hook.) Christ, Bull. Herb. Boiss. **II, 2:** 554. 1902.

Type: Chile, *Meyen*.

I have seen a specimen in the herbarium in Berlin-Dahlem collected in Chile by Meyen and marked "*Blechnum* (*Lomaria*) *microphyllum* n. sp." (Morton photograph 10180). This is surely an isotype and possibly the holotype. I do not know the location of Goldmann's holotypes. This species is not, as indicated in Christensen's "Index Filicum," a synonym of *Blechnum penna-marina* (Poir.) Kuhn, but is identical with *Blechnum gayanum* (Rémy & Fée) Sturm, as suspected by Gualterio Looser in his revision of the genus *Blechnum* in Chile[1]. However, since he had not seen the type, Looser placed *Lomaria microphylla* Goldm. among the dubious species. In the "Index Filicum," *Lomaria gayana* is also referred erroneously to *B. penna-marina*, but, as shown by Looser, it also belongs with the species that has been generally known as

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[1] Revista Universitaria (Universidad Catol. de Chile) **32**(2): 7–105, *fig. 1—16*. 1947.

Lomaria germainii Hook. or *Blechnum germainii* (Hook.) Christ. Additional synonyms, according to Looser, are *Blechnum andicola* (Phil.) C. Chr. and *B. araucana* (Phil.) C. Chr. A Chilean specimen collected by Werdermann has been distributed under the unpublished name "*Blechnum nivale* Reimers, n. sp."

LOMARIA SETIGERA Gaud. Ann. Sci. Nat. [Paris] **5:** 98. 1823 = *Blechnum magellanicum* Desv. var. **angustiseta** (Bory) Morton, ***comb. nov.***

Lomaria magellanica β angustiseta Bory ex Dumont d'Urville, Ann. Linn. Soc. [Paris] **4**: 597. 1825 [1826]. Based on *Lomaria setigera* Gaud.

Blechnum magellanicum (Desv.) Mett. var. *setigerum* (Gaud.) C. Chr. Ark. för Bot. **10**(2)**:** 9. 1910. Based on *Lomaria setigera* Gaud. Incorrect, since the earliest varietal name was not adopted.

Blechnum tabulare (Thunb.) Kuhn var. *setigerum* (Gaud.) Capurro, Anais Prim. Reun. Sul-Amer. Bot. **2:** 124. 1940. Incorrect, since the earliest varietal name was not adopted.

Type: Iles Malouines, i.e. Falkland Islands, Antarctic South America, *Gaudichaud* (holotype P, Morton photograph 4406).

PTYCHOPYLLUM MAGELLANICUM Klotzsch, Linnaea **18:** 533. 1844 [May–Aug., 1845] = *Hymenophyllum seselifolium* K. B. Presl.

Hymenophyllum magellanicum (Klotzsch) Kunze, Bot. Zeit. **5:** 226. 1847. (**wrongly attributed to "Willdenow"**).

It is unfortunate that the species well known in southern South America as *Hymenophyllum magellanicum* (Klotzsch) Willd. must now be called *H. seselifolium* K. B. Presl, a name perhaps never used since its original publication. Presl published this species in his little book "Hymenophyllaceae" which is dated "1843" but which probably came out in 1844 (see William T. Stearn, J. Soc. Bibl. Nat. Hist. **3:** 15. 1954). Klotzsch's name *Ptychophyllum magellanicum* is in a volume of Linnaea dated "1844," but Stafleu's recent and invaluable "Taxonomic Literature" establishes the actual date of publication as between May and August, 1845. Thus Presl's name has clear priority of a year or more. Klotzsch based his new species on a plant from the Straits of Magellan in the Willdenow Herbarium (no. 20245) in Berlin and on a specimen from Chiloé Island collected by Philippi. Presl's type came from Chiloé also, a collection of Hugh Cuming

(no. 6, presumably in the Presl Herbarium in Prague).

Another name for this species is *Didymoglossum magellanicum* Desv. (Mém. Soc. Linn. Paris **6:** 331. 1827), which was based on a collection merely indicated as from South America. The holotype is in the Desvaux Herbarium in Paris (Morton photograph 4596); it was very likely collected by Commerson. Desvaux and Klotzsch independently adopted the epithet "*magellanicum*," a naturally appropriate name considering the locality involved. Although Desvaux' name is the earliest for this species, it may not now be transferred to *Hymenophyllum* because there is already the name *Hymenophyllum magellanicum* (Klotzsch) Kunze, which although taxonomically the same is not nomenclaturally the same since it is based on a different type.

MERTENSIA MAGELLANICA Desv. Mém. Soc. Linn. Paris **6:** 201. 1827.

Desvaux attributed this name to Poiret, referring to Poiret in Lamarck. Encycl. Méth. Suppl. **3:** 669. 1813; however, at this place there is no species called *Mertensia magellanica*. The epithet *magellanica* must be derived from the Straits of Magellan, and the only species on the page cited by Desvaux that is from this locality is *Mertensia quadripartita* Poir. This is however only an inference, although a logical one, and so the name *M. magellanica* Desv. must be considered a *nomen nudum*, since there is no description and no complete reference to a description under another name. That the inference mentioned above is correct is shown by a specimen in the herbarium of the Muséum National d'Histoire Naturelle, Paris, where a specimen from the Desvaux Herbarium is labelled "*Mertensia magellanica* Poiret" in the hand of Desvaux (Morton photograph 4530); this specimen is from the Straits of Magellan, *Commerson*, and is in fact an isotype of *Polypodium quadripartitum* Poir. (in Lam. Encycl. Méth. **5:** 543. 1804), which was later called *Mertensia quadripartita* (Poir.) Poir. The name "*M. magellanica*" was very likely merely a slip of memory on the part of Desvaux, but it has gotten into the literature.

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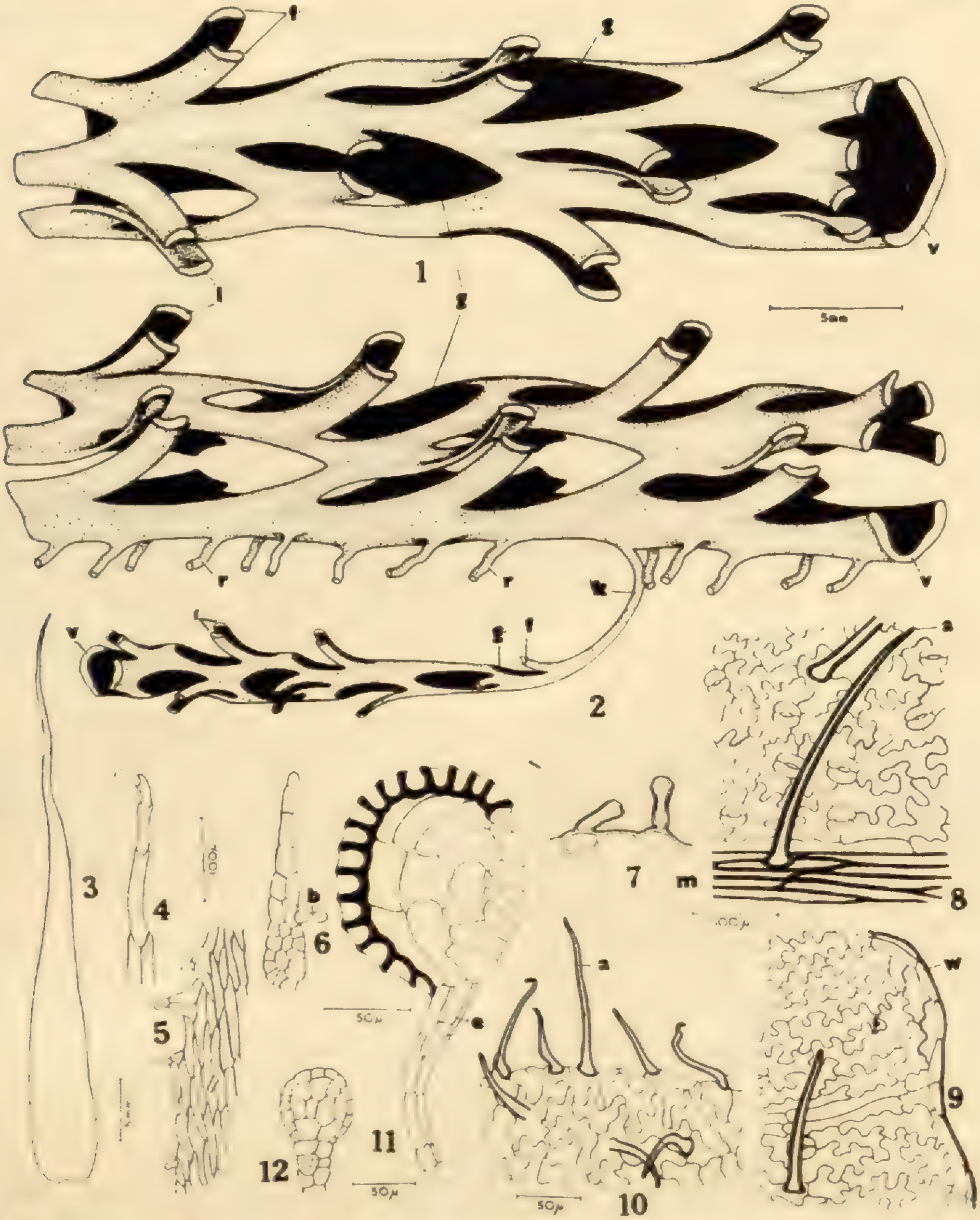
A Reinvestigation of the Morphology of Hypodematium crenatum

B. K. NAYAR AND NISHA BAJPAI

Taxonomically as well as phylogenetically the small fern genus *Hypodematium* remains a problematic one. It includes the widespread, pantropic species *H. crenatum* (Forsk.) Kuhn and perhaps three or more other species, each of limited range in the China–Japan region; some pteridologists detect as many as 16 species. The genus has been associated with the woodsioid, tectarioid, athyrioid, and thelypteroid ferns by different taxonomists, and in some cases even by the same taxonomist at different times. Morphologically the genus is little known except for some aspects of *H. crenatum* published by Hayata (1927), Mehra and Loyal (1956), Loyal (1960), and Iwatsuki (1964a, b). Since the descriptions of these authors contain some discrepancies, we thought it worthwhile to reinvestigate the morphology of *H. crenatum* and to see whether the morphology of this plant could yield some additional clues as to the relationships of the genus.

Material for this study was collected growing in rock crevices from Chakrata (Central Himalaya) and was then cultivated in the fernery of the National Botanic Gardens. Spore morphology was studied using standard palynological techniques, as described by Nayar and Devi (1964). Prothalli were grown on sterilized nutrient agar medium in petri dishes maintained at $24 \pm 2°$ C and at about 600 ft-c light intensity, as described by Nayar (1962). The light source was fluorescent "day light" lamps for 12 hours in each day. Vascular organization of the rhizome was studied from steles excavated mechanically from the rhizome, as well as from reconstructions based on camera lucida drawings of serial microtome sections.

THE RHIZOME is thick, creeping, cylindrical, bears several dormant branches on the ventral surface, and is densely covered by basally attached, golden brown, lanceolate, thin-walled paleae about 30×3 mm (*Fig. 3*) mixed with profuse, unicellular, papillate, glandular hairs (*Fig. 7*). The apex of the palea is uniseriate and



Morphology of the Sporophyte of Hypodematium crenatum. Fig. 1. Vascular cylinder of a portion of the rhizome, dorsal view. Fig. 2. Same, lateral view. Fig. 3. Mature palea. Fig. 4. Same, apex. Fig. 5. Same, margin. Fig. 6. Immature palea at stage marginal hairs are produced. Fig. 7. Papillate hairs on rhizome. Fig. 8. Lower leaf epidermis. Fig. 9. Upper leaf epidermis. Fig. 10. Portion of indusium showing acicular hairs. Fig. 11. Mature sporangium. Fig. 12. Immature sporangium showing origin of third row of stalk cells. The abbreviations are: a = acicular hair, b = glandular hair, e = secondary row of stalk cells, f = leaf trace, g = leaf gap, k = branch trace, m = cells over vein, w = marginal cells, r = root trace, and v = ventral meristele.

is terminated by a non-glandular, barrel-shaped cell (*Fig. 4*). Young paleae bear sparse, unicellular, papillate, glandular hairs (*Fig. 5*) on the margin and both surfaces. The hairs are formed early during development of the paleae, sometimes when the paleae are only three cells broad (*Fig. 6*), and are deciduous. Filamentous, marginal protrusions bearing hairs are found occasionally on the basal region of the paleae. The rhizome is parenchymatous, with small, globose or ovoid masses of thick-walled cells with dark brown contents scattered irregularly in the ground tissue. In rhizome transections these sclerenchyma masses appear like the sclerenchyma strands found in many dryopteroid ferns, but they are not elongate strands. The vascular cylinder of the rhizome (*Figs. 1, 2*) is distinctive and, as reported by Mehra and Loyal (1956) and Iwatsuki (1964a, b), has a broad, undivided ventral half and a dissected dorsal half, recalling that of the Lomariopsidaceae (Nayar & Kaur, 1965). In the adult rhizome there are generally three irregular rows of leaf gaps dissecting the dorsal half of the stelar cylinder—not two alternating rows, as reported by Iwatsuki (1964a, b). The leaf gaps are clearly arranged in a spiral around the vascular cylinder, with a larger distance between successive gaps on the ventral side. The lateral leaf gaps are markedly displaced towards the dorsal median plane. The leaf gaps are large and spindle-shaped and dissect the dorsal half of the stele into narrow, ribbon-like vascular strands. Leaf traces (*Figs. 1, 2*, f) are paired, ribbon-like strands, and the leaf gap extends conspicuously on the abaxial as well as on the adaxial side of them. Root traces are restricted to the ventral, undissected portion of the stele, and originate as thick, superficial, cylindrical branches; they are not associated with the leaf gaps. Branch traces (*Fig. 2*, k) are profuse and are restricted to the ventral half of the stelar cylinder. They are similar to the root traces in being cylindrical, solid strands arising superficially on the stelar surface (not associated with any branch gap) and oriented in the same way (not at the margins of the ventral meristele, as Mehra and Loyal (1956) reported). While passing through the cortex of the rhizome, the branch trace becomes medullated and at the branch base it is

siphonostelic. In developed branches it becomes dissected into a radially symmetrical dictyostele with spirally arranged leaf gaps, but as the branch thickens and grows away from the main rhizome, the ventral leaf gaps become displaced and the ventral half of the vascular cylinder becomes undissected. The xylem tissue of the vascular cylinder is massive and often has 10–12 rows of tracheids that are liberally mixed with thin plates of xylem parenchyma. The phloem forms a thin sheath around the xylem, but is discontinuous at the region of the leaf gaps (margins of the ribbon-like meristeles). The pericycle is three- or four-layered, and the endodermal cells occasionally have faintly thickened inner walls.

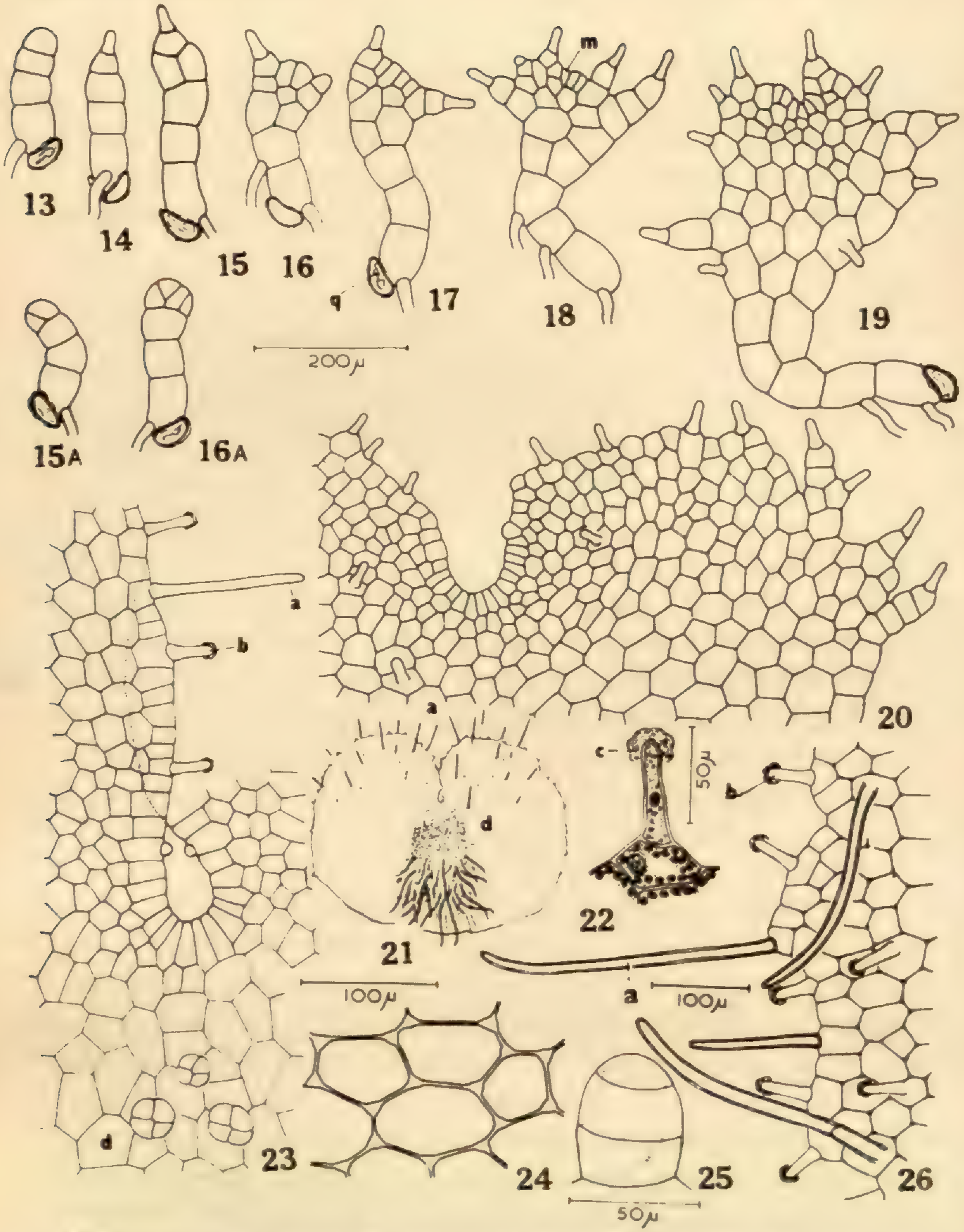
THE LEAVES are crowded, with the leaf bases persistent and densely aggregated on the dorsal surface of the rhizome. The leaf bases are conspicuously swollen and tuberous, as reported in *Pteris wallichiana* (Chandra & Nayar, 1970). Many of the lateral leaves are undeveloped except for their swollen bases; the upper part of such leaves is represented by a deciduous, hump-like protrusion. The swollen leaf bases bear profuse paleae and unicellular hairs. They are parenchymatous like the rhizome and possess scattered sclerenchyma masses; dense deposits of starch occur in the parenchyma cells. The stipe above the swollen base is sharply delimited, nearly cylindrical, and hard due to a broad hypodermal sheath of 5–8 layers of very thick-walled cells. The epidermis is thin-walled and bears unicellular hairs. Sclerenchyma masses are absent in the stipe. The vascular supply consists of a pair of broad, laterally placed strands, with the inner walls of the endodermal cells conspicuously thickened and dark brown. The leaves are shed where the stipe joins the swollen leaf base, but, as noted by Iwatsuki (1964a, b), there is no clear abscission tissue such as occurs in ferns with distinctly articulated leaves (e.g., the Polypodiaceae). A layer of cells of the stipe next to the swollen base turns brown in the old leaves and ultimately shrivels up, resulting in the shedding of the anterior part of the leaf.

The rachis and its branches are subterete with a more or less flat adaxial surface. The two vascular strands of the stipe fuse by their abaxial margins into a solitary bundle, which is nearly

trigonal in the anterior half of the rachis. Xylem tissue of the rachis, bundle is deeply adaxially channeled (U-shaped), with broad, thin, prominently incurved, flap-like margins. Phloem entirely surrounds the xylem in a thin sheath, and the pericycle which surrounds the phloem is one cell thick, except on the adaxial side, where it is much thicker and fills the concavity of the vascular strand.

The lamina is herbaceous and decompound. The ultimate segments are oblong, with blunt apices and a broadly lobed margin. Venation is pinnate, with pinnately branched main lateral veins corresponding to the marginal lobes. Elongate, unicellular or occasionally bi- or tri-cellular, acicular, achlorophyllous, thick-walled hairs, often with peg-like protuberances on the inner surface of the cell wall (*Fig. 8*), are found all over the lamina, more profusely on the veins and axes. Epidermal cells of the lamina, other than those over the veins, are thin-walled, chlorophyllous, and with a broadly sinuous contour; cells of the lower epidermis have a more conspicuously sinuous outline than those of the upper epidermis. Epidermal cells over veins (*Figs. 8, 9*, m) on both surfaces differ in being achlorophyllous, narrow with a smooth contour, and conspicuously elongate parallel to the vein. Similarly, the cells at the margin of the lamina (*Fig. 9*, w) are achlorophyllous, with smooth contour, thickened peripheral walls, and are elongate parallel to the margin. This band of specialized marginal cells is continuous along the margin of the pinnules and becomes more than one cell broad at the basal region of the pinnules and at the sinuses between the marginal lobes, recalling the sinus-membrane of the thelypteroid ferns. The bands of elongate, achlorophyllous epidermal cells above the veins extend to the margin and merge with the marginal band.

THE SPORANGIA are produced in circular sori borne medianly on the lateral veinlets. The sorus is protected by a deeply reniform, basally attached indusium composed of a single layer of cells resembling the cells of the foliar epidermis. Acicular hairs similar to those on the lamina, but often having hooked apices, are profuse on the outer surface as well as on the margin (*Fig. 10*); the marginal



MORPHOLOGY OF THE GAMETOPHYTE OF HYPODEMATIUM CRENATUM. FIGS. 13–19. STAGES IN PROTHALLIAL PLATE DEVELOPMENT. FIG. 20. APEX OF YOUNG CORDATE PROTHALLUS. FIG. 21. ADULT PROTHALLUS. FIG. 22. MARGINAL PAPILLATE HAIR. FIG. 23. ADULT PROTHALLUS, APEX. FIG. 24. SAME, WING CELLS. FIG. 25. ANTHERIDIUM. FIG. 26. ADULT PROTHALLUS, ANTERIOR MARGIN WITH HAIRS. The abbreviations are: a = ELONGATE RHIZOID-LIKE HAIR, b = PAPILLATE SECRETORY HAIR, c = EXTRA-CELLULAR SECRETION, d = ARCHEGONIA, and q = SPORE COAT.

hairs often are larger than the superficial ones. Sporangia (*Fig. 11*) are the typical leptosporangiate type, with a long stalk composed of four tiers of elongate cells. The stalk is two cells thick, with the rows contiguous with either end of the annular ring, except at the capsule base, where there is a third row two cells long formed secondarily during sporangial development as a downward outgrowth of the basal cell of the capsule wall on one of its flat sides (*Fig. 12*). The annulus consists of 16–20 indurated cells.

THE SPORES are monolete and bilateral with a smooth, dark brown exine and loose, densely granulose perine that is wrinkled into short, thin, sparse, lobate folds. The spores average 32 μ $\times$ 45 μ (P $\times$ E, exclusive of perine) and are planoconvex in lateral view and oblong in polar view. The laesura is about 30 μ long and crassimarginate. Spore germination is the Vittaria-type (Nayar & Kaur, 1968).

THE PROTHALLIA develop basically like the *Aspidium*-type (Nayar & Kaur, 1969), and exhibit a full range of variation with respect to early formation of hairs. In the majority of cases the terminal cell of the germ filament becomes quiescent and produces a crowning unicellular hair (*Figs. 13, 14*). A lopsided prothallial plate is developed by the activity of the penultimate cells (*Figs. 15–17*). A second hair is developed on the more expanded side of the plate, and this is usually followed by the establishment of a lateral meristematic cell between the two hairs. The growing apex of the prothallus soon becomes symmetrical, with a median meristematic cell (*Fig. 18*). Many thalli omit a meristematic cell stage. In a few cases hair formation is rather delayed during prothallial development, and a prothallial plate is formed by the activity of the terminal cell of the germ filament (*Figs. 15A, 16A*). In such cases the young prothallial plate is symmetrical and naked. Soon, however, a terminal hair develops on the plate and the plate becomes asymmetric due to unilateral growth. The prothalli become distinctly cordate about 40 days after spore germination. A pluricellular meristem replaces the meristematic cell (or in thalli which skip the meristematic cell stage, a meristem is established directly from anterior marginal cells) when the apex

of the thallus becomes cordate (*Figs. 19, 20*). Young thalli are profusely hairy. The hair-bearing marginal cells frequently become protruded and sometimes form short protuberances two cells long, making the prothallial margin irregular (*Fig. 20*).

The prothalli reach maturity about 60 days after spore germination. The adult prothallus (*Fig. 21*) is of the common, cordate-thalloid type; it is symmetrical, nearly circular, 6–7 mm across, and has a median midrib 6–8 cells thick, and broad, flat wings. The wing cells possess collenchyma-like thickenings at the corners (*Fig. 24*). Unicellular papillate hairs are profuse all over the thallus; the hair-bearing marginal cells are prominently protruded. The hairs are thin-walled, chlorophyllous (with chloroplasts markedly smaller than those in other prothallial cells), and secretory, the secretion forming a prominent, tough, waxy cap crowning the hair (*Fig. 22*). In addition, all the adult prothalli (not some of them only, as Loyal (1960) reported) bear profuse, much elongate, rhizoid-like hairs ("bristles") on the anterior margin and surfaces. These are thin-walled, unicellular (*Figs. 23, 26*), and sparsely chlorophyllous like the papillate hairs, but are several times longer, more highly vacuolated, and devoid of any secretion. Occasionally both types of hairs have one or two transverse septae in their basal half. Hairs intermediate in size between papillate hairs and rhizoid-like hairs also occur, and these commonly have a scanty secretion. "Acicular hairs similar to those on the lamina of fronds" that Loyal (1960) reported were not found on the prothallus.

Sex organs are of the common type found in advanced leptosporangiate ferns. The antheridium is subglobose with a funnel-shaped basal cell (*Fig. 25*). The cap cell collapses at antheridial dehiscence. The archegonial neck is slender and curved away from the apex of the prothallus; the neck is not straight, as Loyal (1960) reported. The neck canal cell is binucleate and swollen toward the tip at maturity.

DISCUSSION

The peculiar combination of common taxonomic characters in *Hypodematium* has rendered the genus phylogenetically ambiguous. It is associated with the woodsioid ferns by Copeland (1947),

the thelypteroid ferns by Ching (1933, 1935, 1940, 1963), the athyrioid ferns by Loyal (1960), and the tectarioid ferns by Holttum (1954) and others. The acicular foliar hairs and paired leaf traces are construed as indicative of thelypteroid affinity, the general morphology of the lamina and its resemblance to *Lastreopsis* as indicative of tectarioid affinity, and the paired leaf traces and basic chromosome count ($n = 41$) as indicative of athyrioid affinity. The chromosome count alone seems sufficient to rule out a thelypteroid relationship, despite the acicular foliar hairs of the thelypteroid type on *H. crenatum*. *Hypodematium* includes species which lack acicular hairs, and so this feature should not be given much weight in phyletic considerations, as Iwatsuki (1964a, b) pointed out. Also, characteristically the paleae of thelypteroid ferns also bear acicular hairs, which are absent in *H. crenatum*, the paleae of which bear instead papillate hairs both on the margin as well as on the surface, as in some of the dryopteroid and athyrioid ferns. The prothalli of thelypteroid ferns have *Drynaria*-type development, in contrast to the *Aspidium*-type characteristic of *Hypodematium* and the dryopteroid and tectarioid ferns. At the same time, *Hypodematium* cannot be held as closely related to the latter groups, mainly because of its binary leaf trace with broad, ribbon-like vascular strands. Both the dryopteroid and tectarioid groups have a large number of slender, cylindrical vascular strands constituting their leaf trace. In addition, the prothallial trichomes, particularly the unique, elongate, rhizoid-like, non-glandular hairs of *Hypodematium*, have no parallel in any of these ferns. The tectarioid ferns, as far as known, possess a few branched, club-shaped glandular hairs on their prothalli, in addition to papillate secretory hairs. The woodsioid as well as the dryopteroid ferns have only papillate hairs. *Hypodematium* resembles the athyrioid ferns in having paired leaf traces and two ribbon-like vascular strands in the stipe, but differs in its characteristic stelar architecture of the rhizome and more significantly in its prothallial morphology; the athyrioid ferns have a *Drynaria*-type, not an *Aspidium*-type, of development.

Hypodematium, therefore, cannot be held to belong to any of the

groups of ferns with which it has been associated in the past by different pteridologists. However, there is little reason to doubt that it is most closely allied to the Dryopteridaceae, as is amply proved by spore and prothallus morphology and chromosome number. That it is an evolutionarily advanced genus is evident from its stelar morphology. It seems clear that the stelar cylinder with leaf gaps restricted to the dorsal surface is derived from a typical dictyostelic condition by displacement of the ventral leaf gaps in response to the peculiar habit of the plant (growing wedged in crevices of hard rock and firmly attached to the substratum), and is not a primitive condition, as suggested by Iwatsuki (1964b). That the ancestral condition is a radially symmetrical dictyostele is indicated by the presence of such a vascular cylinder at the bases of rhizome branches, which gradually progresses to the fully developed form by displacement of ventral leaf gaps. The presence of suppressed leaves on the rhizome is another such indication. It is only the lateral leaves towards the ventral surface that are suppressed, and not any of the median ones. Occasional suppression of some of the ventral leaves and displacement of ventral leaf gaps towards the dorsal surface occur in some genera of the Dryopteridaceae which include some species with erect rhizomes and others with creeping or semi-erect rhizomes, like *Polystichum* (Chandra, 1969) and *Tectaria*. A similar suppression of ventral leaves is encountered also in the creeping species of *Oleandra* (Nayar et al., 1968). Also, the leaf gaps of *Hypodematium* exhibit a distinct spiral arrangement on the stelar cylinder; they are not in two or three dorsal, longitudinal rows, as described by Mehra and Loyal (1956) and Iwatsuki (1964a, b). A unique feature of *Hypodematium* is its branch traces, which are solid, superficial strands on the ventral surface of the rhizome and resemble root traces. Such branch traces are not reported in any other fern with which *Hypodematium* has been associated. They recall the stolons produced by *Nephrolepis*.

It seems best to regard *Hypodematium* as an isolated genus in the Dryopteridaceae, as suggested by Nayar (1970). It represents a line of evolution coordinate with the dryopteroid, athyrioid,

and tectarioid ferns, but distinct from them. The latter three groups and *Hypodematium* each may be considered a subfamily of the Dryopteridaceae.

LITERATURE CITED

CHANDRA, P. 1969. Morphological and Phylogenetic Studies on some Aspidiaceae: Polystichoid and Thelypteroid Ferns. Ph.D. Thesis, Agra Univ.

CHANDRA, S. and B. K. NAYAR. 1970. Some aspects of the morphology of the rhizome of Pteris wallichiana. Proc. Indian Acad. Sci. **71**:79–85.

CHING, R. C. 1933. On the nomenclature and systematic position of Polypodium dryopteris L. and related species. Contr. Biol. Lab. Sci. Soc. China **9**:30–40.

———. 1935. On the genus Hypodematium Kunze. Sunyatsenia **3**:3–14.

———. 1940. On natural classification of the 'Polypodiaceae.' Sunyatsenia **5**:201–268.

———. 1963. A reclassification of the family Thelypteridaceae from the mainland of Asia. Acta Phytotax. Sinica **8**:289–335.

COPELAND, E. B. 1947. Genera Filicum. Chronica Botanica, Waltham, Mass.

HAYATA, B. 1927. On the systematic importance of the stelar system in the Filicales. Bot. Mag. Tokyo **41**:697–718.

HOLTTUM, R. E. 1954. Flora of Malaya, vol. 2. Ferns of Malaya. Gov't. Printer, Singapore.

IWATSUKI, K. 1964a. On Hypodematium Kunze. Acta Phytotax. Gebot. **21**:43–54.

———. 1964b. Taxonomy of the thelypteridaceous ferns, with special reference to the species of Japan and adjacent regions. II. Circumscription of the group. Mem. Coll. Sci. Univ. Kyoto, B, **31**:1–10.

LOYAL, D. S. 1960. Some observations on the gametophyte of Hypodematium crenatum (Forsk.) Kuhn with a note on the phyletic affinities of the genus. J. Indian Bot. Soc. **39**:133–139.

MEHRA, P. N. and D. S. LOYAL. 1956. Some observations on the cytology and anatomy of Hypodematium crenatum. Curr. Sci. **25**:363–364.

NAYAR, B. K. 1962. Morphology of the spores and prothalli of some species of the Polypodiaceae. Bot. Gaz. **123**:223–232.

———. 1970. Classification of the homosporous ferns. Chapter II *in* B. K. Nayar and S. Kaur, Companion to Beddome's Handbook to the Ferns of British India, Ceylon & Malay Peninsula. Chronica Botanica, Delhi.

———, and S. DEVI. 1964. Spore morphology of Indian ferns. I. Aspidiaceae. Grana Palynol. **5**:80–120.

———, and S. KAUR. 1965. Studies in the fern genera Bolbitis and Egenolfia. I. The adult sporophytes of some species. J. Linn. Soc. Bot. **59**:127–140.

————, and ————. 1968. Spore germination in homosporous ferns. J. Palynol. 4:1–14.
————, and ————. 1969. Prothallial development in homosporous ferns. Phytomorphology 19:125–135.
————, N. BAJPAI, and S. CHANDRA. 1968. Contributions to the morphology of the fern genus Oleandra. J. Linn. Soc. Bot. 60:265–282.

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Shorter Note

PYRROSIA PRINCEPS, A FERN NEW TO CULTIVATION.—I have recently received for identification from Mr. J. W. Peterson an unidentified fern that is being cultivated in Longwood Gardens from material collected by R. G. Wilson in New Guinea and Bougainville (*Peterson J-1087*, collected Jan. 12, 1970). It proves to represent a species previously unknown in cultivation and very restricted in its natural distribution:

PYRROSIA **princeps** (Mett.) Morton, comb. nov.

Polypodium princeps Mett. Ann. Lugd. Bat. **2:** 232. 1866. TYPE: New Guinea, *Zippel* (holotype L, Morton photograph 833).
Cyclophorus princeps (Mett.) C. Chr. Ind. Fil. 200. 1905.

This is a characteristic species, known to me from only three collections (aside from the type) from New Guinea: Auga River, in clumps among rocks near river, alt. 580 m., Papua, Sept.–Nov., 1933, *Brass 5492*; terrestrial in edge of forest on riverbanks, Biniguni Camp, Gwariu River, Milne Bay District, Papua, July 30, 1953, *Brass 23703*; on limestone cliffs, Biak Island, December 2, 1945, *Grether & Wagner 4220*. From the data on the label of the cultivated plant it appears that the species may occur also on Bougainville Island, Solomon Islands.

In habit this species is quite different from the commonly cultivated *Pyrrosia lingua* (Thunb.) Farwell, which has long-stalked fronds scattered along an elongate, creeping rhizome. The rhizome is compact and larger in *P. princeps*, and the fronds are fasciculate. The fronds are probably the largest in the genus *Pyrrosia*, reaching more than a meter in length and 10 cm. in

width. The fronds are essentially exstipitate, which distinguishes them from such species as *P. grandissima* (Hayata) Ching. The Indian *Pyrrosia costata* (K. B. Presl) Iwatsuki and the Philippine *P. splendens* (K. B. Presl) Ching are similar in the frond outline, but the indument is quite different, the scales being dimorphous, the layer of peltate scales being underlain by white, dissected scales with elongate frizzy arms. In *P. princeps* the scales of the lower surface are monomorphous, all like, with numerous, short spreading arms.—C. V. MORTON, *National Museum of Natural History, Washington, D.C. 20560.*

Recent Fern Literature

A COMMENTARY ON SOME TYPE SPECIMENS OF FERNS IN THE HERBARIUM OF K. B. PRESL, by R. E. Holttum. Nov. Bot. Inst. Univ. Carol. Prag. **1968**:3–57. June, 1969.—The study of fern types has in some respects only begun. Original specimens were to a certain extent neglected until the twentieth century. The earliest paper that I recall specifically on fern types is that of Christensen in 1910 on some of the types of Swartz. Probably no others were published until 1936, when Weatherby wrote a most valuable paper on the American types of Desvaux, and 1937, when Christensen wrote on the types of Cavanilles and Cesati. In 1954 I began a general study of fern types, which has continued up to the present time. This is a gigantic task I shall never finish, for I estimate that there are in excess of 50,000 fern types to be located and studied. The Czech botanist K. B. Presl described many species between 1825 and 1851. His types have been in Prague ever since but they have almost never been consulted, which is unfortunate since some of his species, although rather fully described for his day, have remained dubious. Dr. Holttum has remedied this by journeying to Prague to locate the Malaysian types, which are among the most important, for most of Presl's new species were based on the Philippine Island collections of Thaddeus Haenke and Hugh Cuming. Presl's herbarium was still unmounted and just as Presl left it when Underwood visited it in 1905, but it is now mounted and filed, partly in the general herbarium of the Bo-

tanical Institute of Charles University and partly in the National Museum, Prague. Holttum gives an interesting account of the history of the herbarium and also of the Haenke collections obtained on the Malaspina Expedition (1789-1794). Holttum's paper gives a commentary on all of Presl's Malaysian collections and gives his current disposition of them. The paper contains a rather large number of typographical errors, which are not at all Holttum's fault but which are attributable to the Czech typesetters' lack of familiarity with English and with some standard botanical practices, such as the setting of new combinations in boldface. The most significant errors I have noted are:

Page 3, paragraph 1, lines 11 and 12 are reversed.

Page 21, line 16: For "Now identified as *Drynaria quercifolia* (Linn.) J. Sm.", read "Now identified as *Goniopteris tetragona* (Swartz) Presl." I obtained the correct reading from Holttum himself, who consulted his original manuscript.

Page 36, line 12: For "1962," read "1862."

The points of interest are far too numerous to mention here, but special mention should be made of the discussion of Presl's genera *Pronephrium* and *Proferea*, the former being an earlier name for *Abacopteris* Fée, if that is recognized as a genus, and the latter a synonym of *Cyclosorus megaphyllus* (Mett.) Ching (= *Thelypteris megaphylla* (Mett.) K. Iwatsuki). Holttum's intensive study of the ferns of this area for more than 40 years renders him uniquely qualified to discuss the taxonomy. I would like to comment only on the treatment of five species, which are mentioned below.

Page 21. *Polypodium plukenetii* Presl is identified as probably identical with *Phymatodes alternifolia* (Willd.) Presl (syn. *Phymatodes nigrescens* (Blume) J. Smith). This misidentification of *Polypodium alternifolium* Willd. with *Polypodium nigrescens* Blume is a mistake of Copeland. Sledge (Bull. Brit. Mus. Nat. Hist., Bot. **2**: 144. 1960) has commented that a photograph of the type in the Willdenow Herbarium in Berlin shows that *alternifolium* Willd. is a form of *Polypodium phymatodes* (i.e. *P. scolopendria*) rather than a synonym of *P. nigrescens*. He says that the type

sheet is a small but fertile frond, by which he must have been referring to Herb. Willd. 19637/1 (which *is* a small, fertile frond); however, there are two other sheets in Herb. Willd., 19637/2 and 19637/3 (all evidently a part of the same collection, India, *Klein*), and these other sheets are large plants which show that *P. alternifolium* Willd. perhaps equals *Phymatodes banerjiana* Pal & Pal (Amer. Fern Journ. **53:** 103. 1963), a species only recently segregated from *P. scolopendria*. I pointed this out to Dr. Pal, but he prefers to keep his species *banerjiana* separate (l.c. 108) on some characters that I can not follow. In any case, *P. alternifolium* is different from *P. nigrescens*; Presl's *P. plukenetii* should therefore be placed as a synonym of *P. nigrescens* and not of *P. alternifolium*. Incidentally, there are plants in cultivation in the United States as *P. scolopendria* that appear to be surely *P. alternifolium*, and such plants are to be expected in botanical gardens elsewhere. The characters of these species are well stated by Pal and Pal.

Page 27. The new combination *Pyrrosia costata* (Presl) Holttum was previously made by Tagawa and Iwatsuki (Acta Phytotax. Geobot. **22:** 100. May, 1967). Tagawa and Iwatsuki cite the wrong basionym *Niphobolus costatus* Presl ex Beddome (Ferns Brit. Ind. *ad t. 120.* 1866, excl. *tab.*), which is a later use of the epithet *costatus* but which is based ultimately on the same type as *Apalophlebia costata* Presl. All these names are based on *Polypodium costatum* Wall. List no. 265. 1828, *nom. nud.*

Page 30. *Blechnopsis malaccensis* Presl is referred to *Blechnum indicum* Burm., which should rather be *B. serrulatum* L. C. Richard. In the "Index Filicum, Suppl. 3" Christensen definitely equated *B. indicum* Burm., previously regarded as dubious, with the common and widespread *B. serrulatum*, but the basis for this opinion is unknown. An examination of the type of *B. indicum* Burm. in Geneva shows that this species is by no means the same as *B. serrulatum*, but is, strangely enough, *Asplenium longissimum* Blume, as annotated on the sheet by Mr. F. Ballard, an identification I can confirm. Fortunately the well-known name *Asplenium longissimum* Blume need not be renamed "*A. indicum*" because there exists (but only very recently!) an *Asplenium indicum*

Sledge (Bull. Brit. Mus. Nat. Hist. **3:** 264. 1965), an entirely different plant.

Page 33. *Diplazium vestitum* Presl. There were two syntypes cited—*Cuming 333* and *336*. Holttum cites *336* as the "Type," but this should be "Lectotype." He stated that he did not find *333* at Prague, which is probably to be explained by Presl's comment (Epim. Bot. 84. 1851) under his *D. grammitoides*, "*Affinis sed diversa species est D. tenerum ex insula Leyte* (*Cuming n. 333*)." This indicates either that *Cuming 333* was a mixture in Presl's Herbarium, one sheet being *D. vestitum* and one an undescribed species that he called "*D. tenerum*," or that Presl changed his mind about the status of *333*. Since Holttum did not find *333* filed as *D. vestitum*, it is likely that the latter is true, and that *333* is filed as "*D. tenerum*." Holttum states that *333* is not represented at Kew; however, it *is* there, filed as *D.* "*sylvaticum*," (Morton photograph 18620) and I have found it also in Firenze (Morton photograph 16124). A peculiar thing is that J. Smith cited *333* as from Samar, and the Kew and Firenze sheets are from Samar and also the specimen cited by Presl as his *D. vestitum*, whereas the specimen mentioned by Presl as "*D. tenerum*" was said to be from Leyte, which was probably an error, since the same number was not assigned to Cuming collections coming from different islands even though the plants might have been considered the same species. The specimens of *Cuming 333* that I have seen are apparently referable to *D. petiolare* Presl and not to *D. vestitum*, which is more divided and more scaly on the rhachis. *Cuming 336* was fixed as lectotype of *D. vestitum* by Hooker (Second Cent. Ferns *t. 46*. 1860 and Sp. Fil. **3:** 260. 1860), who referred only *Cuming 336* to *Asplenium vestitum* (Presl) Hooker, and cited *333* under *A. sylvaticum* (*l. c.* 248. 1860).

Page 51. In his early and valuable work on *Stenochlaena* (Gard. Bull. Str. Settl. **5:** 259. 1932), Holttum identified a rather common and distinctive Malaysian species as *Stenochlaena laurifolia* Presl (Epim. Bot. 164. 1851), admittedly without having seen either the type or the original description, which is quite understandable, Presl's books being rare and his specimens in Prague very remote

from Singapore, where Holttum was working at the time. Now on seeing Presl's type (*Cuming 226*) he is certain that *S. laurifolia* Presl is a synonym of the common *S. palustris* (Burm.) Bedd., and that the species that he called "*S. laurifolia*" in 1932 needs a name. He remedies this by proposing "*Stenochlaena cumingii* Holttum, nom. nov.—*S. laurifolia* (non Presl) Holttum, Gard. Bull. Str. Settl. **5:** (1932) 259; Copel., Fern Fl. Philip. 428." But this is an entirely inadmissible procedure, for one can give a new name only to a validly published species that is in need of a new name; a misidentification is not a validly published species. This is not a new name but a new species, and as such it requires a Latin diagnosis and a designation of a type, neither of which Holttum provides. Therefore, *S. cumingii* Holtt. is a *nomen nudum*, not validly published. Dr. Holttum should provide a proper description and a designation of a type to validate this name, which is needed.—C.V.M.

REVIEWS OF TROPICAL AFRICAN PTERIDOPHYTA, 1, by E. A. C. L. E. Schelpe. Contributions from the Bolus Herbarium, No. 1, published by The Bolus Herbarium, University of Cape Town, Rondebosch C. P., Republic of South Africa, pp. 1–132. 1969. Price 2 Rands.—There are at present no general treatments of the ferns of tropical Africa, although there are some fine regional treatments, such as Madame Tardieu's "Les Pteridophytes de l'Afrique Intertropical Francaise," (1953), pteridophytes in the "Flore du Gabon," (No. 8, 1964), and "Flore de Cameroun," (No. 3, 1964), and Alston's "The Ferns and Fern-Allies of West Tropical Africa," (Suppl. ed. 2, The Flora of West Tropical Africa, 1959). East tropical Africa has been unworked, except for the papers on Ethiopia by Pichi-Sermolli, and so Dr. Schelpe's new treatment will be of great value to students everywhere. This first part discusses the families Grammitidaceae, Azollaceae, Salviniaceae, Vittariaceae, Lomariopsidaceae, Adiantaceae, and Polypodiaceae (sens. restr.). The Grammitidaceae are considered to contain two genera, *Grammitis* and *Xiphopteris* (incl. *Ctenopteris*); my union of these into the single genus is termed by Schelpe "a rather extreme standpoint," although Schelpe separates

these genera only by the character "Frond simple, entire to shallowly crenate" as opposed to "Frond pinnatifid to deeply pinnatifid," and adduces no other characters; there are in fact no other characters. Since I do not know of any other fern genera that are separated only by the character of blade division, and that only a difference between blades shallowly crenate as opposed to pinnatifid, my viewpoint does not seem unduly extreme. In fact, many fern genera that have blades normally pinnatifid to compound have some species with simple blades, e.g. *Adiantum*, *Trichomanes*, *Lindsaea*, *Polystichum*, *Thelypteris*, *Asplenium*, *Polypodium*, in fact many large genera.

The new combination *Xiphopteris albobrunnea* (Baker) Schelpe is proposed, based on *Polypodium albobrunneum* Baker (1877), but *Polypodium sechellarum* Baker (1874) is prior. Schelpe rejects the latter on the ground that it was based on two elements, one of the syntypes representing *X. albobrunnea* and the other *X. villosissima* subsp. *subpinnata*. Schelpe also states that the original description is not conclusive as to which element should bear the name *sechellarum*, and so rejects the name for either. This is contrary to the Code and to usual taxonomic procedures, which provide the workers should select lectotypes where these have not been provided. These lectotypes can be and frequently are quite arbitrary, where there is no special reason to select one rather than another element. But here there is a clear choice, since one of the syntypes is from the Seychelles Islands and the other from Mauritius; since Baker chose the specific epithet "*sechellarum*" he obviously had this Seychelles specimen in mind, and so it should be the lectotype. Therefore, I here designate *Horne 194* (K), from Mahé, Seychelles, as lectotype, which means that this epithet replaces *albobrunnea*. The following new combination is thus necessary: *Grammitis* **sechellarum** (Baker) Morton (*Polypodium sechellarum* Baker in Hook. & Bak. Syn. Fil. ed. 2, 508. 1874). Those who wish to continue to recognize *Xiphopteris* as a distinct genus will have to make the appropriate new combination.

Salvinia rotundifolia Willd. is recognized as adventive in the Lukungo River, Congo, but as I pointed out (Contr. U. S. Nat.

Herb. **38:** 75. 1967) this species has been misidentified by recent authors; the type in the Willdenow Herbarium is clearly a synonym of *S. auriculata* Aubl. I am not quite sure of the proper name for the species that has been called *S. rotundifolia* by Weatherby and others, but it may be *S. minima* Baker. Schelpe also records *S. auriculata* Aubl. from Lake Kariba, where it is a serious pest; however, I have had an intimation from workers who are studying this problem that the Lake Kariba plant is not really *A. auriculata*, but a sterile pentaploid, which would indicate that it is probably a recent hybrid that is spreading solely by vegetative means.

Schelpe's treatment of *Elaphoglossum* is going to be especially useful, because this is one of the most difficult genera throughout the tropics. The key is based almost wholly on scale characters, which is doubtless inevitable, since the species are so uniform in most ways other than the scales. Recent studies of the stipe anatomy and spores indicate that there may be some additional usable characters.

It is an open question whether *Pteris quadriaurita* Retz. is a species or an aggregate of many nearly allied species. Schelpe indicates that the question is not solved; in his treatment he is conservative and recognizes only one species, with four subspecies, which are not keyed out. *Cheilanthes*, one of the larger genera treated, is regarded in an inclusive sense, including *Notholaena* and *Aleuritopteris*, although *Aspidotis* is segregated, but *Polypodium* is split up, following Ching's lead, into *Pleopeltis*, *Phymatodes*, *Microgramma*, *Microsorium*, and *Polypodium*.

It should be mentioned that Schelpe recognizes *Phymatodes* K. B. Presl (Tent. Pterid. 195. 1836) as a valid genus, but in publishing this generic name Presl cited as synonyms *Dipteris* Reinw. and *Microsorium* Link, both earlier validly published and legitimate genera. Therefore, by Art. 69 of the Code, *Phymatodes* Presl was a superfluous name, and consequently illegitimate, since the earlier name *Dipteris* should have been adopted instead of a new generic name. *Phymatodes* is, by Art. 7, Note 4, typified by the type of the name that ought to have been adopted, namely by *Dipteris conjugata;* it is a straight synonym of *Dipteris*. The name

Phymatodes could be used in Schelpe's sense by conservation, but this hardly seems necessary. Its group is a small one, and is usually united with *Microsorium*, even by those who split up *Polypodium*, such as Copeland, who is by no means conservative in his recognition of genera in this group. Schelpe separates *Phymatodes* from *Microsorium* by the former having paraphyses in the sori and the latter not, but even if true this is not necessarily a generic character, and that it is always true remains to be demonstrated. Schelpe had only a single species of *Phymatodes* and only two, closely allied, of *Microsorium*. The numerous Malaysian species of these groups have hardly been investigated.

Schelpe uses the spelling "*Microsorium*," as is usual and correct in my opinion. The name was originally spelled "*Microsorum*" by Link (Hort. Berol. **2**: 110. 1833), and this spelling was adopted by Sledge in his treatment of the Polypodiaceae of Ceylon, but it was later changed by Link himself (Fil. Sp. 116, 135, 1841) to *Microsorium*. The Greek "soros," generally Latinized as "sorus," is masculine, and if Link had wanted to make a generic name from it he would have called it "*Microsorus*," just as he proposed *Cyclosorus* and *Camptosorus*. Instead, he evidently intended a diminutive, the Greek "-ion," Latinized usually as "ium," on the analogy of *Pteridium*, and so the original ending "um" was properly corrected to "ium."—C.V.M.

A NEW NAME FOR A SPECIES OF POLYPODIUM FROM NORTHWESTERN NORTH AMERICA, by Frank A. Lang. Madroño **20**: 53–60. 1969.—Lang has investigated the western *Polypodium hesperium* Maxon cytologically and finds that there are two cytotypes, a diploid and a tetraploid, which can be distinguished morphologically. The type of *P. hesperium* corresponds to the tetraploid; it has the sori oval and medial, the rhizome with a sweetish, licorice taste, and the rhizome scales without a dark median stripe. It occurs mostly in the interior, east of the Cascade Mountains. The diploid has the sori circular and submarginal, the rhizome acrid, and the rhizome scales often with a median dark stripe. It occurs mostly in the western mountains from British Columbia to the Sierra Nevada, but there are a few specimens from elsewhere

(Wyoming, Colorado, Arizona). This diploid plant is called "*Polypodium montense* F. A. Lang, nom. nov.," and *Polypodium amorphum* Suksd. Werdenda 1: 16. 1927, is cited as a synonym (Type: *Suksdorf 11667*). The holotype of *P. montense* is said to be *Lang 211*. This shows a confused concept, for if *P. montense* is a "nom. nov." i.e. a new name for a species previously published then it must have the same type as the earlier name, that is, the type of *P. montense* would have to be *Suksdorf 1166*. Actually, since Lang gives a new Latin description and cites a new and different type, his species is apparently really considered a new species. However, it is in my opinion a superfluous name, since the legitimate species *P. amorphum* Suksd. is cited as a synonym and that name should have been adopted. Lang's reason for rejecting *P. amorphum* is that he considers it a monstrosity to be rejected under Art. 71 of the Code. He defines a monstrosity as "a plant that deviates greatly from the natural form of character, is abnormal, or is malformed," but this is by no means what the Code means by a monstrosity. A true monstrosity would be something like *Spondylantha* Presl, which was based on a plant of *Cissus sicyoides* that was so transformed by a smut that it was not recognizable as a *Cissus* at all. But *Polypodium amorphum* is not like that at all; it merely has somewhat abnormal leaves but they are recognizable as belonging to Lang's species since it is cited as an unquestionable synonym. Many species have been described from somewhat abnormal specimens, e.g., *Polypodium trifurcatum* L., which was based on a plant with the fronds forked at the apex; the name obviously applies to a common West Indian species. So far as I know no plant with the leaves forked at the tip has ever again been found, yet no one has ever questioned the validity and legitimacy of the name *P. trifurcatum*. Therefore, the name *P. montense* must be rejected as a superfluous new name for *P. amorphum* Suksdorf.—C.V.M.

FLORA PALAESTINA, PART ONE, TEXT, by Michael Zohary. Israel Academy of Sciences and Humanities, Jerusalem, 364 pp. + 2 maps. 1966.—This flora, which includes the pteridophytes of Israel, is not new but has only recently come to my attention. As might be imagined from its aridity, Israel is not a "ferny"

country. In fact, there are only 15 species of pteridophytes that grow there. Any Fern Society members visiting Palestine will be able to identify the ferns they see merely by recognizing the genera, for each genus is represented usually by only one species. As a matter of fact, the families are so finely split that there is mostly only one species in each. The species are: *Equisetum telmateia, E. ramosissimum, Ophioglossum lusitanicum, Cheilanthes fragrans, C. catanensis* (*Notholaena vellea*), *Adiantum capillus-veneris, Pteris vittata, Anogramma leptophylla, Thelypteris palustris, Asplenium adiantum-nigrum* subsp. *onopteris, Ceterach officinarum, Phyllitis sagittata, Dryopteris villarii* subsp. *australis, Polypodium vulgare* var. *serratum*, and *Marsilea minuta*.—C.V.M.

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C. V. MORTON ROLLA M. TRYON

IRA L. WIGGINS

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American Fern Journal

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A Major North American Range Extension for the Forked Spleenwort, Asplenium septentrionale

David L. Emory[1]

The "Forked Spleenwort," *Asplenium septentrionale* (L.) Hoffm., is a very unusual Spleenwort and one of the most striking ferns in the American flora. Presumably because of its peculiarly attenuated leaves (*Fig. 1*), the plant was recently referred to by Darling, (1964, p. 200) as an "oddity." Nevertheless it is a very wide ranging plant. Its distribution in western North America has been summarized by Lang (1969), who found the species recently for the first time in Oregon. Because of its "striking resemblance to tufts of grass" and its tendency to occur in very localized populations, it probably occurs in other as yet undiscovered places in the western United States; at present it is known there from the eastern slope of the Rockies from South Dakota and Wyoming south to western Oklahoma, New Mexico, Arizona, and Baja California. In the Old World, Broun (1938) reports it from the British Isles, Europe, northern Asia, and the Himalayas. Of the seven species of Spleenworts known in Britain, Manton (1950, p. 98) writes that "The rarest is *Asplenium septentrionale* . . ., a plant of southern affinities only found in a few presumably relict localities in the mountains of England, Scotland, and Wales." The habitat given by Broun is "sheltered crevices in cliffs of igneous rocks."

During the second term of the 1970 summer session at Mountain Lake Biological Station of the University of Virginia, I was enrolled in the Pteridology course which has been taught there since 1961 by Dr. Warren H. Wagner, Jr., of the University of Michigan. A major emphasis in this course is upon student research in the field and laboratory. Accordingly, on August 2, 1970, a committee from

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[1] I wish to thank Mrs. Carolyn Crump for the photographs and Dr. Florence S. Wagner (working under NSF Project GB–8113) for the chromosome observations.

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Bluff in Monroe Co., West Virginia, where A. septentrionale Grows

the class, consisting of Carolyn Crump, Ronald and Shirley Fortney, Lewis Morgan, and me, began a pteridological survey of Monroe County, in southeastern West Virginia. This county, which is adjacent to Giles County, Virginia (the location of the Biological Station), seemed especially promising for field exploration because the class had already visited locations there discovered by E. T. Wherry during the late 1930's for *Phegopteris connectilis* and *Lycopodium porophilum*, which are growing at this southern latitude at unusually low elevations for these northern plants.

While we were climbing on the upper slopes of a bluff of loose, strongly brittle shale above a stream (*Plate 16*), we noticed what appeared to be several tufts of a small grass or sedge growing from crevices in the exposed, brightly sunlit, and extremely dry shale. In color, size, and texture, the narrow leaf tufts also seemed quite similar to bunches of pine needles. Closer examination revealed, however, that these "needles," some of which were four inches long, were actually slightly expanded near their tips and forked. They bore on their undersides unmistakable fern sporangia. Having seen *Asplenium septentrionale* on the American Fern Society Colorado Foray in 1964, I quickly realized that we had made a remarkable discovery. Consultation of the literature indicated that our plants were nearly 1,200 miles from the nearest known station in western Oklahoma.

When Dr. Wagner and the entire class visited the area on the following day, we counted sixty plants from four to nearly 40 feet above the stream level on the northwest-facing bluff. Diligent searching up and down the stream revealed five more plants on another cliff about one-fifth of a mile upstream. One of the latter plants is shown in *Figure 1*, growing from the same crevice as *A. platyneuron*.

As these plants on both cliffs were of all ages, the populations are definitely reproducing. Unless some calamitous disturbance takes place, the ferns should be able to maintain themselves indefinitely. We have no idea how old the populations are. It is entirely possible that other stations will be discovered, as there are numerous similar habitats nearby.

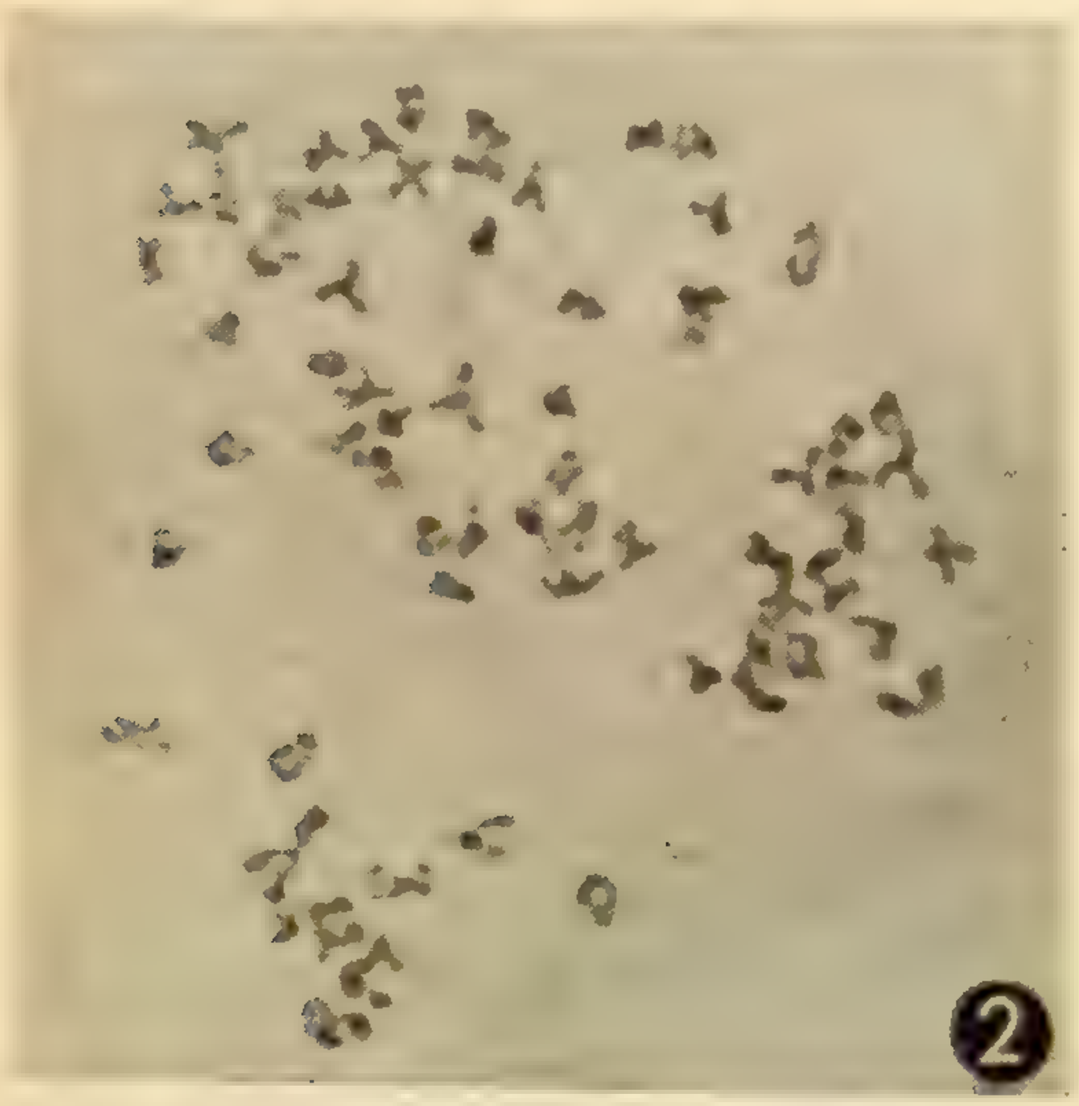

Fig. 1. Asplenium septentrionale (above) growing from same crevice as A. platyneuron (below). Fig. 2. Chromosomes of A. septentrionale at meiotic metaphase. Fig. 3. Same, camera lucida interpretation.

Because of its great disjunction and the possibility that the local populations have become differentiated, we were especially interested in determining the chromosome number. Manton (1950, p. 98ff.) reported that *A. septentrionale* in Great Britain is tetraploid ($n = 72$ pairs at diakinesis). Cytological preparations of the plants we obtained, made by Dr. Florence S. Wagner, showed unmistakeably the same number (*Figs. 2, 3*).

The "Septentrionale Bluff," at an elevation of about 2100 feet, is shown in *Plate 16*. It supports only a sparse vegetation. Trees include *Pinus virginiana*, *P. strobus*, *Quercus primus*, *Q. ilicifolia*, *Betula lenta*, and *Robinia pseudoacacia*. Among the shrubs are *Vaccinium vacillans*, *Kalmia latifolia*, *Rhus radicans*, and *Parthenocissus quinquefolia*. The herbs *Aquilegia canadensis*, *Houstonia longifolia*, and the attractive *Campanula divaricata* are in evidence here, the last in bloom at the time of our discovery of the fern. The loose shale is extensively covered by a variety of lichens (especially such fruticose types as *Cladonia rangiferina*) and a few mosses, including *Polytrichum* spp. and *Leucobryum glaucum*.

Ferns associated with the Forked Spleenwort are *Asplenium trichomanes* and *A. platyneuron*. In Great Britian and Europe *A. septentrionale* hybridizes with the first to yield *A.* × *germanicum* (Manton, 1950, p. 100ff.). This is the first time that *A. septentrionale* and *A. platyneuron* have been reported growing together. No hybrid plants of the latter parents have yet been discovered.

A number of fronds collected from several plants on both days of our visits (*Emory 70019, 70020*) have been distributed to the following herbaria: US, GH, NY, MICH, WVA, and TENN. More precise information on the location in Monroe County, West Virginia, is not being published in the hope that the population can be protected. I do not feel that there is a need for oversampling, and I wish to urge the greatest caution in maintaining these plants in their natural state without disturbance.

This report of *Asplenium septentrionale* in the Appalachian region constitutes a new addition to the flora of the eastern United States. The significance of disjunct eastern localities for western fern species will be discussed in another paper.

LITERATURE CITED

BROUN, M. 1938. Index to North American ferns. 217 pp. Science Press, Lancaster, Pa.

DARLING, T. 1964. Southwest Vacation. Amer. Fern J. **54**: 197–205.

LANG, F. A., 1969. The first record of Asplenium septentrionale (L.) Hoffm. in Oregon. Amer. Fern J. **59**: 45–47.

MANTON, IRENE. 1950. Problems of Cytology and Evolution in the Pteridophyta. xi + 316 pp. Cambridge Univ. Press.

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Hard Water as a Limiting Factor in the Distribution of Isoëtes echinospora

LEROY LEE AND FRANCES BELKNAP

Isoëtes in Wisconsin has been shown by Swindale and Curtis (1957) to be a typical member of the soft water flora. Tryon et al. (1953) show it distributed in soft water areas, but absent from areas where hard water lakes are common. Moyle (1945) reports the Quillworts in Minnesota as members of a flora limited to a single chemical type: the soft water lakes found in the northeastern portion of the state.

Although soft water is the typical location of Quillworts, they have been found in hard water. Lee reports *Isoëtes echinospora* from Moshawquit lake. This Wisconsin lake has a specific conductance of 173 micromhos/cm and a total alkalinity of 98 mgm/l $CaCO_3$, which exceeds the upper limit of tolerance as reported by Moyle (1945). Seddon (1965) reports it in two hard water lakes in Wales, Llyn Llygerian and Llyn Llywenan.

Moyle (1945) suggests that the aquatic species of *Isoëtes* are found in soft water because they can not tolerate a total alkalinity

of above 50 mgm/l $CaCO_3$, but since they have been reported from other than the usual soft water sites, the distribution can not be completely attributed to water chemistry. Seddon (1965) concluded from field observations that competition is responsible for the restriction of *I. echinospora* to soft water.

To determine if Quillworts could survive and grow in hard water without competition, *I. echinospora* var. *braunii* (Dur.) Engelm. was grown under laboratory conditions of varying water chemistry during one summer growth period.

TABLE I. WATER ANALYSIS OF EXPERIMENTAL TANKS[1]

	total alkalinity ($CaCO_3$ mgm/l)	*pH*	*conductance (micromhos/cm)*	*water color* (Pl–Co *units*)
Crooked Lake	29	7.5	119	15
Crystal Lake	92	7.6	231	35
Wis. River	112	8.2	282	65
Fish Lake	148	7.9	304	35
Pretty Lake	160	8.3	483	40
Lake Ripley	184	8.6	431	20
Lake Wingra	228	7.8	643	38
Merrill Springs	281	8.0	585	30

[1] Water analysis furnished by Mr. Ronald Poff, Water Classification Specialist, Wisconsin Department of Natural Resources, Madison, Wisconsin.

Eight 10-gallon aquaria were filled with water and substrate, each from a specific body of water. Water sources were chosen to provide a range from very soft to very hard water (see *Table I*). Experimental plants were collected from Crooked Lake, Burnett County. For each tank, ten plants were randomly selected from the collection, weighed, the number of leaves counted and measured, and then planted. Twelve hours of light was supplied daily by Gro-lux fluorescent bulbs to provide 100 ft-c of illumination at the water surface. Weekly water analyses determined that little change in water chemistry occured over the experimental period.

At the end of 21 weeks all plants were still surviving in the soft water control (Crooked Lake) and the hard water aquarium from Ripley. Seventy per cent of all the experimental plants survived; they grew an average of 5 new leaves and had 2 cm of leaf and root growth, the same as the average in the soft water control tank. Sporulation did not occur.

At the termination of the experiment the plants were replanted, additional hard tap water (280 mgm/l $CaCO_3$) was added to each tank to replace evaporation loss, and continuous illumination at a high intensity was provided. After five months all plants still survived and appeared healthy. Several were sporulating.

While the results of this experiment are tenuous due to the death of 30% of the experimental plants, they do support the belief that water hardness is not the single major limiting factor in distribution. The continued growth and sporulation with increased illumination, plus the fact that the two tanks which had 100% survival were significantly less colored than the others (see *Table I*), indicates that the amount of light reaching the plants may be an important factor in the distribution of *Isoëtes echinospora* var. *braunii*.

LITERATURE CITED

MOYLE, J. 1945. Some chemical factors influencing the distribution of aquatic plants in Minnesota. Amer. Midl. Nat. **34**: 402–420.

SEDDON, B. 1965. Occurrence of Isoëtes echinospora in eutrophic lakes in Wales. Ecology **46**: 747–748.

SWINDALE, D. and J. CURTIS. 1957. Phytosociology of the larger submerged plants in Wisconsin lakes. Ecology **38**: 397–407.

TRYON, R., N. FASSETT, D. DUNLAP, and M. DIEMER. 1953. The ferns and fern allies of Wisconsin. 158 pp. University of Wis. Press, Madison, Wis.

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Indian Pteridophytes Used in Folk Remedies

H. S. PURI[1]

The medicinal qualities of ferns, real or imaginary, are mentioned as early as 300 B.C. by the Greek philosopher Theophrastus (Corne, 1924a) and by his Indian contemporaries Sushrut and Charak. Dioscorides also speaks of brake fern, male fern, and others. Among the medicinal plants mentioned in old Indian texts, two are definitely ferns. One of these, called "Myurshikha" or "Myurpankha," meaning peacock's feather, has been identified as *Adiantum caudatum* L. by some persons; others consider it to be *Actiniopteris radiata* (Swartz) Link. The other drug called "Hanspad" or "Hansraj," meaning swan's foot, appears to be some species of *Adiantum*, most probably *A. capillus-veneris* L., *A. lunulatum* Burm. f. or *A. venustum* D. Don. In addition to these plants there are about 40 species of pteridophytes used as drugs. Of these *Dryopteris filix-mas* (L.) Schott is included in the pharmacopoeias of many countries. In the 1955 Pharmacopoeia of India this plant is replaced by the allied species, *D. odontoloma* (Moore) C. Chr., *D. marginata* (Wall.) Christ, and *D. schimperiana* (Hochst.) C. Chr., and in the 1966 Pharmacopoeia of India by *D. odontoloma*, *D. marginata*, *D. chrysocoma* (Christ) C. Chr., *D. ramosa* (Hope) C. Chr., and *D. barbigera* (Hook.) Kuntze. *Lycopodium clavatum* is included in the Indian Pharmaceutical Codex (Mukerji, 1953) and in the proposed Indian Homeopathic Pharmacopoeia. *Equisetum arvense* L. is included in the U.S.S.R. Pharmacopoeia (1961) and in the German Pharmacopoeia (Wealth of India), and Puri (1969) has recommended its inclusion in the Indian Pharmacopoeia. The species of *Adiantum* mentioned above are used unofficially in some of the patented cough preparations marketed in India. The rest of the plants mentioned below are used in domestic and rural medicines.

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[1] The author is greatly indebted to Prof. P. N. Mehra for his keen interest and to Mr. C. V. Morton for his kind suggestions during the preparation of this article.

Actiniopteris radiata (Swartz) Link.—Used as an anthelmintic (Watt, 1889; Kirtikar & Basu, 1935; Chopra et al, 1958; Chunekar & Pandey, 1969), as an alterative in prolonged malarial fevers (Nadkarni, 1954; Chopra et al.), and as an astringent to arrest hemorrhages (Chunekar & Pandey).

Adiantum aethiopicum L.—Infusion of leaves used as an emollient in coughs and diseases of the chest (Caius, 1935).

Adiantum capillus-veneris L.—According to Watt, the bulk of *Adiantum* sold medicinally in India is this species. A decoction of the fronds of this plant is considered quite effective in all types of bronchial troubles (Watt; Nadkarni; Steinmetz, 1954; Wren, 1956; Uphof, 1959). An infusion of the herb serves as a shampoo against dandruff and also promotes hair growth (Watt; Steinmetz; Wren). The plant is considered as an emmenagogue (Nadkarni; Uphof). The juice of the plant with pepper is recommended for all types of fevers (Nadkarni; Biswas, 1955). It is used for hydrophobia by the physicians of the Persian system of medicine (Watt).

Adiantum caudatum L.—Fronds used for diabetes, coughs (Kirtikar & Basu; Chopra et al), and for migraine (Stewart, 1869). Also used externally for skin diseases (Chopra et al).

Adiantum lunulatum Burm. f.—One of the constituents of Hansraj, the drug esteemed in India for coughs. It is considered a bronchio-dilator, diuretic (Chopra et al) and pectoral (Caius). In western India used extensively in the treatment of fevers of children; the rootstock is considered good for fever and elephantiasis (Kirtikar & Basu).

Adiantum venustum D. Don—According to Kirtikar and Basu the fronds of this plant are the source of the Indian drug Hansraj. Because of the black color of the stalks of the fronds, it is sometimes known by the name of black Hansraj. The plant is administered as an anodyne in bronchitis and is considered a diuretic and emmenagogue (Stewart, Kirtikar & Basu; Chopra et al). It is a tonic, febrifuge, and expectorant, and is particularly useful as a tonic during convalescence from fevers (Caius).

Asplenium adiantum-nigrum L.—A decoction or syrup of the fronds is used as an emmenagogue (Kirtikar & Basu). It is bitter,

diuretic, and laxative, and is considered useful in ophthalmia and diseases of the spleen and jaundice. It is believed to cause sterility in women (Chopra et al.).

Asplenium falcatum Lam.—Used in enlargement of the spleen, incontinence of urine, calculus, jaundice, and malaria (Kirtikar & Basu).

Asplenium ruta-muraria L.—It is used for rickets (Chopra et al), and as an expectorant (Nadkarni) and deobstruent (Kirtikar & Basu). According to Steinmetz, "Herba Rutae Murariae" is an expectorant and cures diseases of the spleen. It prevents hair from falling and makes it grow (Fernie, 1914; Steinmetz).

Asplenium trichomanes L.—Considered a laxative (Fernie; Chopra et al) and anthelmintic (Nadkarni). The leaves are sweet, mucilaginous, and are an expectorant highly useful in pulmonary disorders (Caius).

Athyrium filix-femina (L.) Roth.—Used as a substitute for the Male Fern, but has been found quite ineffective (Chopra et al).

Botrychium spp.—Various species of this genus, such as *B. lunaria* (L.) Swartz, *B. ternatum* (Thunb.) Swartz (Chopra et al), and *B. virginianum* (L.) Swartz (Kirtikar & Basu), are used in dysentery, ruptures, and for healing wounds (Wealth of India).

Cibotium barometz (L.) J. Smith—The rhizome is used as a vermifuge and the root as a tonic. The long, silky, yellowish hairs at the base of the fronds cause rapid coagulation of the blood and when properly used are useful for arresting hemorrhages from capillaries (Wealth of India). The root is employed as a tonic in China, where it is said to exercise a special action on the genito-urinary organs (Kirtikar & Basu). Used in typhoid and in the treatment of dyspepsia and coughs (Chopra et al).

Drynaria quercifolia (L.) J. Smith.—The rhizome is bitter, tonic, and astringent to the bowels. It is also used in typhoid and in the treatment of dyspepsia and coughs (Chopra et al). A decoction of the rhizome is used as an astringent (Uphof).

Dryopteris filix-mas (L.) Schott.—One of the oldest anthelmintic drugs, commonly known as Male Fern, and used since ancient

times for expelling tape-worms from the intestines. This fern does not grow naturally in India, but various allied species which are up to British Pharmacopoeial and United States Pharmacopoeial standards are used (Indian Pharmacopoeia, 1955, 1966). The use of *D. filix-mas* does not appear to be harmless. According to Steinmetz, its application may cause paralysis of the muscles and nerves, and even blindness. This may be due to the presence of the enzyme thiaminase, which destroys thiamin (Pohl, 1955).

Equisetum arvense L.—"Herba Equisiti Arvensis" has diuretic and astringent qualities (Steinmetz; Wren) and is quite useful for urinary and bladder diseases (Uphof), and for stopping the flow of blood in urine (Steinmetz). An oral administration produces a decided increase in blood corpuscles. The plant is used for acidity of the stomach and dyspepsia. (Wealth of India).

Equisetum debile Roxb.—Diuretic and astringent (Biswas), and given for gonorrhoea (Stewart).

Helminthostachys zeylanica (L.) Hook.—The plant has intoxicating and anodyne properties and is used in sciatica (Chopra et al; Wealth of India). Rhizome used for malaria (Uphof). The Malays regard the rhizome as a tonic, and eat it with betel for whooping cough. In Java used for dysentery, catarrh, and the early stages of phthisis (Wealth of India).

Lycopodium cernuum L.—In Malaya a decoction of the plant used as a lotion in beri-beri and also for coughs and uneasiness in the chest. An embrocation of the ashes in vinegar is recommended for skin eruptions (Wealth of India).

Lycopodium clavatum L.—Mainly the spores of this plant are used in medicine. English druggists included this powder in their list of drugs before 1692. It was introduced in the U.S. Pharmacopoeia of 1860 (Whitebread, 1941). This drug has been used internally with good results in urinary disorders, such as the spasmodic retention of urine, catarrhal cystitis, and chronic kidney diseases causing pain in the kidney, ureter, and bladder (Wren; Nadkarni; Biswas). Also used in dyspepsia, catarrhal gastritis, and as a general and gastric sedative (Wren). The plant is also given to stop hemorrhages after childbirth (Biswas). In the form

of a tincture it is given for rheumatism, epilepsy, and pulmonary disorders (Nadkarni). An aqueous extract of it has been employed in various countries as an antipyretic (Wealth of India, 1962).

Sometimes the spores of *L. annotinum* L., *L. complanatum* L. and *L. selago* L. are also used for the above purposes (Wealth of India). Frequently *Lycopodium* spores are adulterated with such substances as slightly roasted and colored starch, dextrin, and various pollens (Whitebread).

The Lycopodium powder has side effects. Whitebread has quoted instances where it has acted as foreign body and has given rise to an indolent chronic post-operative inflammatory reaction. The alkaloids of this drug have also been found harmful to warm-blooded animals. A variety of reactions, such as pressor effects, stimulation and contraction of the uterus, and paralysis are attributed to these alkaloids (Wealth of India).

Lygodium circinnatum (Burm. f.) Swartz—The spikes of this plant are reported to be used in Indonesia as an external application for wounds (Wealth of India).

Lygodium flexuosum (L.) Swartz—Used as an expectorant. Fresh rootstocks are applied externally for rheumatism, sprains, scabies, eczema, and cut wounds, and are reported to be particularly useful for carbuncles (Caius).

Lygodium japonicum (Thunb.) Swartz—Used as an expectorant. In China a decoction of the vegetative parts and spores is used as a diuretic (Wealth of India).

Lygodium microphyllum (Cav.) R. Brown—A decoction of leaves given for dysentery. Leaves are also applied as poultices for skin diseases and swellings (Kirtikar & Basu).

Marsilea quadrifolia L.—This is probably the plant used in ancient India under the name of "Sparka" for leprosy and skin diseases, fever, and for poisoning of blood (Chunekar & Pandey).

Ophioglossum vulgatum L.—The leaves boiled in oil or fat are considered a remedy for wounds. This preparation cools inflammation (Fernie; Chopra et al).

Osmunda regalis L.—Considered a tonic and styptic, and used against rickets (Chopra et al). The middle part of the plant boiled

in liquid is considered good for wounded persons. The rootstock, stamped in water or gin until the liquor becomes a stiff mucilage, has been used to cure back pains (Fernie).

Polypodium vulgare L.—An infusion of "Herba Polypodii" is a mild laxative and expectorant. An aqueous extract of "Rhizoma Polypodii" is recommended in the obstruction of viscera, liver and gland diseases, and coughs and chills (Steinmetz). In northern India this or a related species is used as an alterative (Stewart).

Polystichum squarrosum (D. Don) Fée—The rhizome of this plant is sold in the Indian market under the name "Nirbissi," and the drug is used as an antidote to poisons; it is a possible substitute for the male fern (Mittal, 1953).

Pteridium aquilinum (L.) Kuhn.—The rhizome is astringent and is useful for diarrhea and inflammation of the gastric and mucous membranes. Boiled in oil or hog's fat, the rhizome is made into an ointment for wounds. A decoction of the rhizome and fronds has been given in chronic disorders arising from obstruction of the viscera and spleen (Wealth of India). It is also used instead of hops (Corne, 1924b).

Pteris ensiformis Burm. f.—The juice of the young plant is stated to possess astringent properties; a decoction of fresh fronds is given in dysentery. The juice of the rhizome is applied in the glandular swelling of the neck (Wealth of India).

Pteris multifida Poir. (*P. serrulata* L. f.)–In China a tincture or decoction of rhizome is given in dysentery. Also said to be a good vermifuge. The toasted fronds and rhizome are made into a paste with sesame oil and applied to the skin afflictions of infants (Wealth of India).

Selaginella spp.—Apparently dry plants of some species appear to become fresh and green again when put into water. Because of this, physicians of the Indian system of medicine use it as a rejuvenator for the human body. It is also given in mental diseases, rickets, blood vomiting, and spermatorrhoea (Chunekar & Pandey).

Tectaria polymorpha (Wall.) Copel.—Used as an anthelmintic (Kirtikar & Basu).

LITERATURE CITED

BISWAS, K. 1955. Common Medicinal Plants of Darjeeling and Sikkim. Botanic Garden, Calcutta.

CAIUS, J. F. 1935. The Medicinal and Poisonous Ferns of India. J. Bombay Nat. Hist. Soc. **38**: 341–361.

CHOPRA, R. N., CHOPRA, I. C., HANDA, K. L., and KAPUR, L. D. 1958. Chopra's Indigenous Drugs of India. U. N. Dhur and Sons, Calcutta.

CHUNEKAR, K. C. and PANDEY, G. S. 1969. Bhavparkash Nighantu (in Hindi). The Chowkhamba Vidya Bhawan, Varanasi, India.

CORNE, F. E. 1924a. Ferns—Facts and fancies about them—II. Amer. Fern J. **14**: 77–82.

————. 1924b. Ibid.—III. Amer. Fern J. **14**: 115–118.

FERNIE, W. T. 1914. Herbal Simples, ed. 3. John Wright & Sons, Bristol.

KIRTIKAR, K. R. and BASU, B. D. 1935. Indian Medicinal Plants, Part IV, ed. 2. Lalit Mohan Basu, Allahabad, India.

MITTAL, T. C. 1953. Pharmacognosy and phytochemistry of some Indian species of Polystichum and Athyrium. M. Pharm. Thesis, Panjab Univ., Chandigarh, India.

MUKERJI, B. 1953. Indian Pharmaceutical Codex, vol I. Council of Scientific and Industrial Research, New Delhi.

NADKARNI, K. M. 1954. Indian Materia Medica, vol I. Popular Book Depot, Bombay.

POHL, R. W. 1955. Toxicity of Ferns and Equisetum. Amer. Fern J. **45**: 95–97.

PHARMACOPOEIA OF INDIA. 1955. Manager of Publications, New Delhi.

————. 1966. Second edition. Manager of Publications, New Delhi.

PURI, H. S. 1969. Scope of including some indigenous medicinal plants in I. P. Indian J. Hosp. Pharm. **6**: 102–106.

STATE PHARMACOPOEIA OF THE UNION OF SOVIET SOCIALIST REPUBLICS. 1961. 9th edition, Moscow.

STEINMETZ, E. F. 1954. Materia Medica Vegetabilis. E. F. Steinmetz, Kaizergracht, Amsterdam, Netherlands.

STEWART, J. L. 1869. Panjab Plants. Gov't. Printing Press, Lahore.

UPHOF, J. C. TH. 1959. Dictionary of Economic Plants. Hafner, New York.

WATT, G. 1889–1892. Dictionary of Economic Products of India, Parts I–IV. W. H. Allen.

WEALTH OF INDIA. 1948–1969. Parts I-VIII. Council of Scientific and Industrial Research, New Delhi.

WHITEBREAD, C. 1941. Beware of "Lycopodium." Amer. Fern J. **31**: 100–102.

WREN, R. C. 1956. Potter's New Cyclopaedia of Botanical Drug and Preparation. Sir Issac Pitman and Sons, London.

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The Rhizome Scales of Platycerium[1]

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Considerable diversity exists in the structure of fern rhizome scales. Although the more conspicuous features of scales have long been used in describing and identifying some groups of ferns, the more detailed aspects have generally been ignored. Modern monographs and treatments on ferns have contributed to a better understanding of the value scales may have in the interpretation of evolutionary relationships. The object of this paper is to describe some of the rhizome scale features of *Platycerium* that seem to be helpful in determining the evolutionary trends within the genus. Some similar features have been pointed out by Wagner (1952, p. 77) in the genus *Diellia*.

Before the rhizome scales could be studied for structures that might be of phylogenetic value, it was necessary to determine first the probable evolution of the *Platycerium* species. For this, I used a variety of characters other than those of the rhizome scales. Reliable characters included stele types, sporangial arrangement, nature of the sporangial stalk, and completeness of the annulus. Only after I had arrived at the probable evolution of the species did I examine the rhizome scales in detail to determine how their features correlated with the patterns I had determined. The three main lines of evolution are summarized in Table I. The Afro-American line includes *P. andinum* and two branches both starting from *P. quadridichotomum*. One branch ends in *P. angolense* and the other branch ends in *P. ellisii*. The sequence of species in the other two lines is essentially linear, as listed.

In selecting rhizome scales for study several factors must be kept in mind. The scales on individual plants vary, but species differences are usually consistent, providing the factors of the age of the plant, weathering, and selection of a typical scale from the sampling are taken into consideration. Immature or small plants

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[1] Research supported by a National Science Foundation Science Faculty Fellowship.

generally have smaller, lighter, and fewer bicolorous scales bearing fewer hairs than those on mature plants. On fully mature plants scales may have suffered damage by weathering and must be assessed accordingly. The best scales for study are those that are starting to darken on full grown plants. Even in perfect material there will be variations; the largest, darkest scales usually show the characters of the species more clearly than the narrower, smaller, lighter colored scales or fibrils. In regards to selection of trichomes for study, Carlquist (1961, p. 33) aptly states, "Each trichome type in each species shows some variability and thus each type should be studied as a *population* having extremes and a typical condition."

The plants used in this study are from cultivation; for most the specific place of collection is not known.[2] Silhouettes of the scales were made by tracing photographs; drawings of the hairs were made with the aid of a microprojector.

MORPHOLOGY AND EVOLUTIONARY SIGNIFICANCE OF SCALES AND THEIR HAIRS

Scale distribution.—Rhizome scales are most conspicuous on the buds, but also cover the entire surface of the stout rhizome and extend up the phyllopodia occasionally to just beyond the abscission layer. On the bud the many light colored scales are tightly overlapped and appressed to the surfaces. Progressing to the older parts of the rhizome, the scales become darker, less appressed, and may twist or curl to form a thick, chaffy covering; they are persistent.

General shape.—Each plant bears scales of various widths and lengths; the larger, darker scales are here considered the representative scales of a species. For most species these are more or less narrowly triangular. However, the scales of *P. andinum* and *P. angolense* (*Figs. 14, 15*) are noticeably linear-triangular, and in *P.*

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[2] Messrs. Ed Franks, Rudy Ziesenhenne, Marcel Lecoufle, and John Roach very generously provided most of the plants and specimens for this study, and I am greatly indebted to them for their many kindnesses. I wish to thank Miss Marie Sanchez for her expert advice in preparing the illustrations and also to acknowledge the assistance and many valuable suggestions given to me by Dr. Mildred E. Mathias. The major part of this work was done at the University of California, Los Angeles, where facilities were kindly provided.

coronarium and *P. ridleyi* they are obovate (*Figs. 29, 30*). All but *P. coronarium* and *P. ridleyi* have fibrils (very narrow scales) which also vary in width and length on the same plant; the narrowest are uniseriate flattened hairs and the widest are indistin-

TABLE I. SPECIES AND THEIR RHIZOME SCALE CHARACTERS

Character states 3 = *very specialized* 2 = *specialized* 1 = *intermediate* 0 = *generalized*	*Fibrils present* (0), *absent* (2)	*Scales narrow* (0), *intermediate* (1), *broad* (2)	*Scales not papery* (0), *papery* (2)	*Apex filiform* (0), *acute* (1), *blunt* (2), *round* (3)	*Base non-peltate* (0), *subpeltate* (1), *peltate* (2)
AFRO–AMERICAN LINE					
P. andinum	0	0	0	0	0
P. quadridichotomum	0	0	0	0	0
P. stemaria	0	0	0	0	0
P. angolense	0	0	0	0	0
P. madagascariense	0	0	0	0	0
P. vassei	0	0	0	0	0
P. ellisii	0	0	0	0	0
JAVAN–AUSTRALIAN LINE					
P. willinckii	0	0	0	0	1
P. veitchii	0	0	0	0	1
P. bifurcatum	0	0	0	1	2
P. hillii	0	0	0	1	2
MALAYAN–ASIATIC LINE					
P. wallichii	0	0	0	0	0
P. holttumii	0	1	0	2	0
P. wandae	0	1	0	2	0
P. grande	0	2	2	3	0
P. coronarium	2	2	2	3	0
P. ridleyi	2	2	2	3	0

guishable from narrow scales. The almost universal presence of fibrils in the genus seems to indicate the ancestral type had fibrils which developed into progressively broader scales. It is generally accepted (Bower, 1923, pp. 201–205) that hairs preceded fibrils and that fibrils developed into scales. Following this line of reasoning,

narrow scales probably gave rise to broad scales. Extremely broad scales (*Figs. 26–30*) seem to be linked to the development of flabelloid margins. The scale length varies from 2 to 35 mm, the longest being those of *P. wandae* and the shortest those of *P.*

Hairs or papillae marginal (0), *submarginal* (1), *superficial* (2)	*Specialized hairs none* (0), *semi-* (1), *mostly* (2), *all spec.* (3)	*Basic hairs none* (0), 1–7-*celled* (1), 8-*celled* (2)	*Specialized hairs none or mostly* 2–5-*celled* (0), 1–2 (1), 1 (2)	*Partial stellate hairs absent* (0), *present* (2)	*Flabelloid margin none* (0), *narrow* (1), *intermediate* (2), *broad* (3)	*Total value of specialized states*
0	2	0	0	2	0	4
0	1	0	0	0	0	1
0	2	0	0	2	0	4
0	1	0	0	0	0	1
1	2	0	1	0	0	4
2	3	0	2	0	0	7
0	1	0	0	0	0	2
0	1	0	0	0	0	2
0	1	0	0	0	0	4
0	1	0	0	0	0	4
0	0	0	0	0	0	0
1	0	2	0	0	1	7
1	1	1	0	0	2	8
1	1	0	0	0	2	11
0	3	0	1	0	3	16
1	3	0	2	0	3	18

willinckii. The scales on the phyllopodia are larger than those on the rhizome. The texture of the scales is usually firm, but some *P. grande* scales are thin and papery and those of *P. coronarium* and *P. ridleyi* are also except at the center; this is probably a specialized condition.

Scale apex.—Scale apices may be long attenuate to acute, to blunt, rounded or emarginate (*Figs. 2–5*). Typically the attenuate apices end in a long, often gland-tipped filament. Acute apices have fewer and stouter cells in the filament; blunt apices are multicelluar and sometimes apiculate or emarginate. The apices may often be branched into a number of hairs or filaments. If it is true that scales have been derived from hairs, then the generalized scale apex would be attenuate and filiform and the specialized apex blunt and multicellular. There would be a trend toward increasingly broad apices. There remains, however, the possibility that the extremely long attenuate apices of *P. angolense* and *P. andinum* may be a specialized condition.

In the clear evolutionary line of the Malayan-Asiatic group there is a series from generalized to specialized apices. The intermediate state consists mostly of acute apices that are rarely filiform. The Javan–Australian group has the generalized to intermediate state; the Afro–American group tends to the generalized.

Scale base.—The scale base may be slightly narrowed, rounded, truncate, or subcordate to cordate (*Figs. 9–13*); however, most are unmodified. Most scales are sessile and attached by the length of their basal edge (*Fig. 9*), which may be a broadened area if the scale is bent and appressed to the rhizome (*Fig. 10*). Scales may also be subpeltate (pseudopeltate) to peltate. In all cases the scales interrupt the rhizome epidermis at their point of attachment. The subpeltate condition (*Fig. 12*), found on some scales of *P. willinckii*, *P. veitchii*, and *P. bifurcatum*, is often accompanied by a subcordate or cordate base; the attaching tissue is a long or short flange. *Platycerium hillii* and some forms of *P. bifurcatum* have weakly peltate scales with rounded bases, which are most frequently found on the phyllopodia and which tend to detach easily (*Fig. 13*). There is a definite stalk or short flange which attaches to the rhizome in a slight epidermal depression. Peltate scales are generally considered more advanced than subpeltate or other unmodified ones (Bower 1923, p. 200).

Scale margin.—The scale margin may be entire, or bear papillae or hairs, or be flabelloid (see the separate discussions on hairs and

flabelloid margin). Small, dark protuberances are sometimes seen on or near the walls of the marginal cells of *P. grande*, *P. wandae*, and *P. bifurcatum*. They seem to be persistent cell nuclei which have not deteriorated, for in the younger parts of the scale nuclear stains bring out obvious nuclei which if examined in progressively older cells move toward the wall and appear as the small dark protuberances.

Bicolorous scales.—The central middle to basal areas of the scale are marked by a stripe on at least some scales of most species. The stripe is composed of cells which have all thickly pigmented brown to black walls. A scattering of lighter colored cells with only their lateral walls thickened may be found among the darker cells. As there is considerable inconsistency in color and pattern of these stripes, it is difficult to use these to evaluate phylogenetic trends. The stripe extends to or nearly to the apex in members of the *P. bifurcatum* group more frequently than in other species. *Platycerium grande* often lacks a well defined stripe, particularly on the larger scales of the phyllopodia.

Scale development.—Rhizome scales begin their development from uniseriate hairs. These hairs divide longitudinally, transversely, and clinally at the thickened center to form the scale. For cell details see *Figure 1*. In non-peltate scales the enlargement of the base is by transverse and longitudinal cell division. Peltate scale development in *P. hillii* often shows a cupping in or turning under of the basal auricles, which are eventually obliterated by thickening, enlargement, and overtopping growth of the whole basal area, resulting in a thick, rounded base (*Fig. 13*). The attaching cells that were between the auricles become submarginal and differentiate into a short flange or well-defined stalk. This scale development is similar to that illustrated for *Pyrrosia* (Nayar, 1961, *figs. 7–15*, p. 166), except that there are no auricles.

Hair distribution.—Hairs are found on all scales except those of *P. wallichii*. All others have hairs along the edge of the scales; the hairs are sparse near the basal edge. *Platycerium bifurcatum* and *P. hillii* tend to have long, tangled hairs near the apical margin of the scales, but this is not always consistent (*Fig. 4*).

Platycerium Rhizome Scales. Fig. 1. P. angolense, young scale, generalized except for hairs. Fig. 2. P. coronarium, mature scale, specialized, margin papery, flabelloid. Fig. 3. P. veitchii, filiform apex. Fig. 4. P. hillii, acute apex. Fig. 5. P. grande, blunt apex. Fig. 6. P. holttumii, margin weakly flabelloid. Fig. 7. P. wandae, margin flabelloid. Fig. 8. P. grande, margin strongly flabelloid.

Hairs on the broad surfaces of the scales are found near the apex occasionally in *P. angolense*, and over much of the surface in *P. ellisii* and *P. vassei* (but more sparsely in the latter), and on the face of the marginal cells in *P. ridleyi*. The dense marginal fringe of hairs in *P. holttumii*, *P. wandae*, and *P. grande* scales (*Figs. 6–8*) arises from marginal and submarginal cells of the flabelloid margin. Having the hairs consistently scattered over the surface of the scale or spreading to a submarginal position occurs in most advanced to moderately advanced species and is to be regarded as more specialized than having hairs limited to marginal cell edges. In the apparently related genus *Pyrrosia*, a similar distribution of hairs is also found among the advanced or moderately advanced species (Nayar, 1965, p. 13).

Hair types.—The hairs found on the rhizome scales fall into three intergrading types: glandular, ray, and basic. The glandular types are typically stout, round at the apex, and contain a dark, gland-like substance. The ray types appear much like the rays of the stellate hairs of the lamina; most are whitish and blunt to pointed at their apex, and generally flat, although some are conical and often a bit darker. Basic hairs are close to the ray type in appearance and color, but are typically bent, twisted, or crooked, and not as flat and white as the ray type. Shorter basic hairs bear a close resemblance to the marginal papillae, whereas longer ones may be setiform. Typical glandular hairs are found in *P. ridleyi* (*Fig. 30*), typical ray types in *P. vassei* (*Fig. 19B*), and basic types in *P. grande* (*Fig. 28B*). Some basic types may blend into the ray type, a common condition in *P. wandae* (*Fig. 27*). All three kinds of hairs and their intermediates are found in the Malayan–Asiatic line (*Figs. 25–30*). The Javan–Australian line (*Figs. 21–24*) and the more primitive members of the Afro–American line (*Figs. 16–18*) have mostly basic to glandular types. Basic to glandular intermediate hairs tend to have the contents of the cell collapsed, causing a distortion of the cells (*Fig. 17*).

Origin of the hair types.—The presence of hair-like papillae and their similarity to basic hairs suggest that basic hairs are derived from elongate papillae. This follows the dictum that trichomes

Platycerium Rhizome Scales and Hairs. Figs. 9–13. Rhizome scale bases, not to scale. Fig. 9. P. stemaria, broad attachment. Fig. 10. P. vassei, broad attachment, scale bent. Fig. 11. P. wandae, subcordate base. Fig. 12. P. willinckii, subpeltate base. Fig. 13. P. hillii, peltate base. Figs. 14–30. Rhizome scales and hairs showing changes along evolutionary lines. Figs. 14–20. Afro-American line. Fig. 14. P. andinum. Fig. 15. P. angolense. Fig. 16. P. stemaria. Fig. 17. P. quadridichotomum.

FIG. 18. P. MADAGASCARIENSE. FIG. 19. P. VASSEI. A, MOZAMBIQUE; B, MADAGASCAR; C, CULTIVATED. FIG. 20. P. ELLISII. FIGS. 21–24. JAVAN-AUSTRALIAN LINE. FIG. 21. P. WILLINCKII. FIG. 22. P. VEITCHII. FIG. 23. P. BIFURCATUM. FIG. 24. P. HILLII. FIGS. 25–30. MALAYAN–ASIATIC LINE. FIG. 25. P. WALLICHII. FIG. 26. P. HOLTTUMII. FIG. 27. P. WANDAE. FIG. 28. P. GRANDE. A, HAIRS FROM MEDIAL MARGIN; B, HAIRS FROM BASAL MARGIN. FIG. 29. P. CORONARIUM. FIG. 30. P. RIDLEYI. The abbreviation is: M = MARGINAL CELLS.

originate from papillate epidermal cells (Netolitzky cited in Carlquist, 1961, p. 34). This hypothesis is supported by the presence in *P. holttumii* and *P. grande* of very short to long papillae intermingled with basic hairs, which are distinct only by the cell wall separating the hair cell from the trichoblast.

Uniseriate hairs are generally regarded as the basic type from which many other variants are derived (Wagner, 1964, p. 90). The origin of the glandular hair is from the basic hair. There are all degrees of gradation between these two types. Also, well defined glandular hairs appear only in the more advanced members of the Malayan–Asiatic (*Figs. 29, 30*) and Afro–American (*Figs. 14, 15, 19, 20*) lines and hence correlate with other advanced traits. The Javan–Australian line has retained the intermediate basic to glandular hairs (*Figs. 21–24*).

The origin of ray hairs is not so clear. In the Malayan–Asiatic line they seem to be derived from the basic type or one tending toward a glandular condition; there are all degrees of gradation between these types in *P. grande* and *P. wandae* (*Figs. 27, 28*). In the Afro-American line the ray hairs are often stouter, conical, and seem to have been derived from glandular hairs. These rays may appear as branches off a glandular hair in *P. angolense*, *P. andinum* (*Figs. 14, 15*), and occasionally in *P. vassei*, or may be independent but intermingled with glandular hairs in *P. ellisii* and *P. vassei* (*Figs. 19, 20*). Occasional hairs intermediate between the glandular and the ray condition may be found near the basal margin in *P. vassei*. The abundance of conical ray hairs also seems to indicate an intermediate condition between glandular and ray hairs. When the contents of the conical ray hair collapse, the ordinary ray with its flat shape is produced. Conical ray hairs are mostly found in the Afro–American line, and basic hairs are mostly absent from it. In *P. ellisii*, the ray hairs tend to originate from the center of the trichoblast cell, rather than from one side, as is frequently the case with hairs close to the basic type in origin. Nayar (1965, p. 13) has described hairs on *Pyrrosia obovata* which seem to be similar in many ways to the ray hairs of *Platycerium ellisii*. *Pyrrosia heteractis*, with the basic type of hair, is considered

by Nayar primitive in relationship to *Pyrrosia obovata*. Nayar implied that the hairs which arise from the center of the cell and have dilated bases as in *P. obovata* are separate entities not related to protuberances in origin. It seems that hairs of this type in *Platycerium* are a result of cell reduction or failure of the basal developing hair cell to elongate properly. Similar dilated hair bases on glandular hairs may be found in some forms of *P. vassei* and in *P. ridleyi*.

Unicellular to multicellular hairs.—Most of the species have hairs with 2–4 cells. But one has only protuberances known as papillae (*Fig. 25*), others have mostly 1-celled hairs (*Fig. 20*), and others have mostly multicellular hairs (*Fig. 26*). It is generally believed that unicellular hairs are more primitive than multicellular hairs unless the unicellular condition is shown to be a reduction (Netolitzky, cited in Carlquist, 1961, p. 34). In the Malayan–Asiatic line of the genus the primitive *P. wallichii* (*Fig. 25*) lacks hairs and has only papillae which presumably gave rise to 1-celled hairs. Hairs with more cells have evolved, and those of *P. holttumii* (*Fig. 26*) have 8 cells. The next species, *P. wandae* and *P. grande* (*Figs. 27, 28*), show a decrease in the number of cells to 5 or fewer. Basic hairs are still present, but semi-specialized hairs (i.e. intermediate glandular and ray types) have appeared. It seems that the appearance of semi-specialized to specialized hairs may be correlated with at least the partial loss of the basic hair types. In *P. coronarium* (*Fig. 29*), an advanced species, the cells in the hair are reduced to 2 and are glandular. The more advanced *P. ridleyi* (*Fig. 30*) has a large percentage of 1-celled glandular hairs. This reduction trend is also found in the Afro–American line, culminating in *P. ellisii* (*Fig. 20*) which bears only 1-celled glandular or ray type hairs. It also seems that the advanced condition for specialized hairs is from many to few cells.

Incomplete stellate hairs.—Ray cells are unicellular (*Fig. 19b*) or are found as terminal or subterminal cells on basic or glandular hairs (*Fig. 14*). Two to several ray cells may appear on the apical cell of a basic or a glandular hair (*Fig. 15*); this condition approaches the stellate hair. A less specialized development pro-

duces a long cell with many lateral ray-like cells along its axis; such hairs are occasionally found on fibrils.

There seems to be a relationship between the stellate hairs found on the lamina and those on the rhizome scales. Rhizome scale hairs apparently show ontogenetic stages no longer present in the development of laminar stellate hairs. The development as studied by Straszewski (1915, p. 277) shows that a laminar stellate hair starts as a glandular cell which divides apically into successive glandular cells that elongate and flatten into rays. By studying a variety of hairs on *P. angolense* scales it is possible to reconstruct a plausible sequence of cell arrangement that could have led up to the stages described by Straszewski.

One might take the point of view that the hairs on the rhizome scale represent reductions from the stellate condition. This seems unlikely, for the cells of a reduced hair would probably be comprised of the component cells of the stellate hair type, i.e. ray and glandular cells. Instead, a continuous array of basic to specialized types of cells are present. Also, if reduction were the case, the most primitive species would have retained more of the stellate hair structure. This is not the case, however, for the species having this condition are not among the very primitive ones.

The stellate hair tendency in scales is best developed in *P. angolense* and *P. andinum*. The other species have other specializations or have not reached the stellate state. The separation of the ray and glandular cells into independent hairs is one type of specialization and is found in *P. ellisii* (*Fig. 20*).

Flabelloid margin.—The cells of the scale margins are generally arranged longitudinally, but may be oriented at various angles, and may even be retrorse (*Figs. 2, 28*). Margins with cells that spread outwards in a fan-like manner Holttum (1957, p. 43) described as flabelloid. Flabelloidly arranged cells may be absent, in clusters, or continuous, well developed or barely so, and they may merge with papillae and trichoblasts.

If cells bearing protuberances, trichoblasts, and basic hairs are essentially similar and if they can unite laterally to each other in varying degrees, it is possible to explain the origin of the flabelloid

margin by lateral fusion of "free" marginal cells. This hypothesis is likely because there is no difference in color and texture between "free" marginal cells and those making up the flabelloid margin, the marginal cells being united in varying degrees up to a typical flabelloid state, and the orientation of the cells in the flabelloid margin being in the same direction as that of "free" hairs. That marginal cells as well as submarginal cells of a flabelloid margin may continue to produce papillae and hairs is further evidence that the cells of the flabelloid margin are basically the same as the marginal cells of unmodified scales. If the "free" hairs on a flabelloid margin unite, a very broad, flabelloid margin as found in *P. coronarium* and *P. ridleyi* is formed (*Fig. 2*). The cells of these broad, flabelloid margins are oriented like many of the "free" marginal hairs in *P. grande*. In summary, the trend in the Malayan-Asiatic line seems to be from marginal cells arranged longitudinally to a narrow flabelloid margin with many "free" hairs to a wider flabelloid margin with few "free" hairs. This trend is absent or poorly developed in the other evolutionary lines of the genus. Where it does appear it is found in advanced species (*P. vassei* from Madagascar, *P. bifurcatum*, and *P. hillii*).

False branching.—False branching occurs in *P. holttumii* (*Fig. 26*) and occasionally in *P. grande*. It is characterized by having one or more hair cells with protuberances. Occasionally the protuberances are separated from the cell by a wall, and then a truly branched condition exists. False branching may be interpreted as a stage toward the fusion of hair cells to form a flabelloid margin. An alternative explanation is that these relatively newly derived basic hairs are still genetically close to the marginal cells and have retained their tendency to form papillae or, alternately, false branches. This seems to be the more adequate explanation, as many of the false branches are not distinct from the papillae of marginal cells.

FUNCTION OF THE RHIZOME SCALES

The most vulnerable part of these sometimes immense plants is the relatively small apical bud. Death of the bud results in death

of the whole plant in species which do not produce lateral buds or buds from the roots. Rhizome scales function to protect the bud from desiccation, animals, and excessive water. Beneath the base fronds old rhizome scales may be found very much intact, covering and protecting the rhizome, although the softer parts of the scales may be worn away leaving only the sclerified stripes.

Protection from desiccation is particularly important in these usually high epiphytes, as they are exposed to more drying conditions than low epiphytes or terrestrial plants. I do not know what animals might attack these plants in their native habitats, but the mass of base fronds is known to be a home for a multitude of organisms. Sowbugs, pillbugs, snails, and slugs are capable of eating through the scales and into the buds, particularly on young plants in cultivation. Small insects would probably have difficulty breaking through the scales covering the bud. I have observed scale insects unable to feed because they were entangled in the hairs of the rhizome scales. The insects were able to attach and feed where the rhizome scales ended on the phyllopodia. Smaller animals, however, could gain entry to the bud and rhizome through the injury inflicted by larger animals or microrganisms. The small larvae of fungus gnats (*Mycelophilidae*) apparently gain entry to the rhizome bud through leaf scars which are perhaps softened by decay or do not suberize well. Termites, birds, and various fungi also have been observed to make their home in the nest fronds as well.

The base fronds usually form a ruffle of tissue over the bud, which diverts the flow of water. Although this ruffle may be said to serve other purposes, it also helps to keep the bud free of excess water. I believe that keeping excess water off the bud tissue is a very important function of the rhizome scales as well. Waterlogged tissues are particularly vulnerable to microrganism infections. If softened areas are produced from such infections, other organisms then readily find their way into the remaining tissue. The glandular hairs and large amounts of oil found in the rhizome scales of *P. bifurcatum*, *P. grande* (Joe, 1964, p. 71), and probably other species must also play some role in rhizome protection.

DISCUSSION

With a knowledge of the rhizome scale characters described above and their distribution among the 17 species, it is possible to infer the kind of scales most likely possessed by the ancestral plant. In *Table I*, *P. wallichii* has the lowest value for specialized rhizome scale characters and probably has scales most closely resembling those of the ancestral plant. The relationships of present day species also may be clarified. For example, the general appearance of the South American species *P. andinum* could place it in any of the three evolutionary lines of the genus, but several rhizome scale characters and other less obvious structures place it closest to the African species. However, of broader interest are the changes in rhizome scale structures that have taken place along with the general evolution of the various species. Some of these changes are limited to a few species, but others are established patterns in this and probably other fern genera.

The following changes which have taken place in rhizome scales of *Platycerium* seem to be correlated with evolution in the genus: fibrils present to absent; width narrow to broad; texture firm to thin papery, at least as a broad margin; apex filiform to non-filiform and multicellular; base broadly attached to subpeltately to peltately attached; hairs restricted to the scale margin to spreading submarginally or centrally; margins mostly with papillae to mostly with basic hairs to mostly with typical rays and/or glandular hairs; hairs absent or basic hairs mostly 1-celled to basic hairs multicellular; simple glandular or ray hairs with many cells to the same with few cells; simple hairs to partly formed stellate hairs; and marginal cells oriented with the length of the scale to flabelloid to very broad flabelloid.

From the rhizome scale characters having phylogenetic value the following generalizations are made:

1. Elaborate scale structure is indicative of advanced species, except where reduction of the hair cells is involved.[3]

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[3] A similar conclusion is reached by R. M. Tryon, Jr., who finds that *Cyathea* scales with the least cellular differentiation are primitive (*in litt.* Sept. 8, 1969).

2. Except in very primitive species, reduction in number of hair cells of simple but not stellate hairs is apparently correlated with increased hair specialization.

3. Hair development on some rhizome scales seems to reflect stellate hair ontogeny and shows stages now absent from the leaf.

4. The flabelloid margin seems to have developed from the union of papillae, trichoblast, and hairs.

5. Peltate scales developed by the folding under of the auriculate or rounded base and subsequent overtopping growth, rather than by the lateral union of the auricles. This is similar to the formation of peltate scales in *Pyrrosia*.

6. One of the important functions of the rhizome scale may be to protect the bud tissue from becoming water-logged.

It seems that greater use may be made of rhizome scales in determining relationships within other genera, providing sufficient features are available. Scale interpretations will be more reliable with some prior knowledge of at least some of the relationships in the group. The use of scale characters will be of greatest help in interpretation of problematic taxa and in reinforcing or supporting other phylogenetic interpretations.

LITERATURE CITED

BOWER, F. O. 1923. The Ferns, vol. I. 359 pp. University Press, Cambridge.

CARLQUIST, S. 1961. Comparative Plant Anatomy. 146 pp. Holt, Rinehart, and Winston, New York.

HOLTTUM, R. E. 1957. The Scales of Cyatheaceae. Kew Bulletin **1**: 41–45.

JOE, BARBARA. 1964. A Review of the Species of Platycerium (Polypodiaceae). Baileya **12**: 69–126.

NAYAR, B. K. 1961. Studies in Polypodiaceae, VII: Pyrrosia. J. Indian Bot. Soc. **40**: 164–186.

NAYAR, B. K. and S. CHANDRA. 1965. Ferns of India–XV, Pyrrosia. Bull. Nat. Bot. Gard., Lucknow **117**: 1–98.

STRASZEWSKI, H. R. 1915. Die Farngattung Platycerium. Flora **108**: 271–310.

WAGNER, W. H., JR. 1952. The Fern Genus Diellia, its Structure, Affinities, and Taxonomy. 167 pp. Univ. Calif. Publ. Bot. **26**(1): 1–212.

WAGNER, W. H., JR. 1964. The Evolutionary Pattern of Living Ferns. Bull. Torrey Bot. Club **21**: 86–95.

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Shorter Notes

STEM CROSS-SECTION PRINTS AID IN IDENTIFYING HORSETAILS. —Stem cross-sections are often required for accurate identification of horsetails. These are difficult to obtain from dry and brittle herbarium specimens. I have found a method for making a printed record of the cross-section of a horsetail specimen quickly and with simple materials. It must be done before the specimen is pressed, but may be affixed to the herbarium sheet later as an accurate record of that aspect of the specimen and may be examined with the naked eye or under magnification. When a horsetail specimen is ready to go into the plant press, a sharp, transverse cut is made across the center of a mature internode. One of the cut surfaces is inked with a fountain or felt pen. Several imprints of the surface can then be made on smooth, non-absorbant paper (the field label if possible). Rough paper will make details difficult or impossible to see, and absorbent paper will change the print's dimensions. Although the first prints may be inked too heavily, others will be perfect, and some will be too light. Unless a good labelling system is used to associate the prints with the particular specimens, the prints should be kept with the specimens in the press. The best prints should be pasted near the specimen label when the specimen itself is mounted.—BARBARA J. GUDMUNDSON, *5505 28th Avenue South, Minneapolis, Minn. 55417.*

PSILOTUM NUDUM SPREADING NORTHWARD.—In 1942 the "Whisk Fern," *Psilotum nudum*, was recorded in Brown and Correll's "Ferns and Fern Allies of Louisiana" as having been collected growing wild in a greenhouse, Krack's Nursery, north of New Orleans, having apparently been accidentally imported with potting soil. A recent publication (Sida **3**: 525. 1970) by Dr. G. Rhodes now reports the species as growing wild in four Louisiana Parishes—Terrebonne, St. Mary, Vermilion, and Lincoln. In the last named the species is some 250 miles north of any previously known locality. It is thus apparent that this plant is spreading northwards rapidly, perhaps from wild plants occurring to the eastward in Alabama or Mississippi.—C.V.M.

TERMINOLOGY OF THE SPORANGIAL STRUCTURES OF EQUISETUM.—Several years ago a population of *Equisetum* × *litorale* with many abnormal cones was discovered by Dr. W. H. Wagner, Jr., near Milan, Michigan. The population was extensive, and had invaded an old bean field. In this dry, sandy habitat, atypical for this hybrid, the strobiliferous stems frequently had cones with proliferated tips (*Fig. 1*). The apex of the cone, instead of ceasing growth as it usually does, reverted to a vegetative condition. This type of teratology has been previously recorded in various species of *Equisetum*, and Gluck,[1] Kashyap,[2] and Tschudy[3] have described the intergradation of fertile and sterile appendages associated with the transition from the strobiliferous to the vegetative apex. The same intergradation, seen here in *E.* × *litorale* (*Figs. 2–7*), reveals an innate capability of the appendages produced by the apex to develop either as vegetative leaves or as sporangium-bearing structures. This indicates that the two structures are homologous, and that the term "sporophyll," a more exact term than "sporangiophore," should be used for these structures. Tschudy[3] argued for the term "sporophyll" on the basis of teratology in *E. telmateia*, and I wish to reiterate it here on the basis of teratology in *E.* × *litorale*.

Since the leaves of Lycophytina, Sphenophytina, and Pterophytina are all apparently independently evolved, calling their sporangium-bearing structures "sporophylls" does not imply any homology between the sporophylls of these groups, but only between the leaves and sporangium-bearing structures within each group.—*Richard L. Hauke*, DEPARTMENT OF BOTANY, UNIVERSITY OF RHODE ISLAND, KINGSTON, R. I. 02881.

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[1] Die Sporophyllmetamorphose. Flora **80**: 303–387. 1895.

[2] Some abnormal cones in Equisetum debile. J. Indian Bot. Soc. **9**: 240–241. 1930.

[3] The significance of certain abnormalities in Equisetum. Amer, J. Bot. **26**: 744–749. 1939.

Fig. 1. Cones of E. × litorale showing proliferation of the tips. Figs. 2–7. Series of selected appendages from the cones in Fig. 1, from a typical sporophyll to a nearly typical sheath segment (leaf).

KINDS OF CYSTOPTERIS IN CALIFORNIA.—Recently John Thomas Howell, while preparing a floristic account of the ferns of the Sierra Nevada, suggested to me a study of the two spore types of Brittle Bladder Fern in that area. I enlarged the project's scope to include all the California collections of *Cystopteris* in the California Academy of Sciences herbarium, more than 120 spore-bearing collections.

Based on spore characteristics, two separate taxa are recognizable, although in general appearance they look identical. Profumo[1] examined the gametophytes of the two types and also found no morphological differences. At times, the two types have been considered separate species, *C. fragilis* (L.) Bernh., with spiny spores, and *C. dickieana* Sim, with non-spiny (rugose-verrucose) spores; the two have also been considered subspecies.

The specimens I examined show that both kinds may occur in the same locality, a fact which was recognized by Profumo and by Hagenah,[2] who occasionally found both mounted on the same herbarium sheet.

Within the Sierra Nevada, 14 collections were the *fragilis* type and 67 the *dickieana* type, a noteworthy excess of the latter. Non-Sierran collections showed 22 *fragilis* type and 20 *dickieana* type, a more even distribution. While both kinds occasionally may occur together, there appears to be a predominance of the *dickieana* type at higher elevations. This corresponds to the findings of Larsen[3] in Greenland, who suggested that *C. dickieana* was a high Arctic species and that *C. fragilis* was a sub-Arctic species.

Perhaps these two taxa should be considered as forms rather than subspecies since their distributions are essentially identical and the only apparent difference is in their spores.—ROBERT B. SETZER, *Allan Hancock Foundation, Dept. of Biology, Univ. of Southern California, Los Angeles, California 90007.*

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[1] Profumo, P. 1969. The gametophyte of Cystopteris fragilis and Cystopteris dickieana. Webbia **23**: 317–328.

[2] Hagenah, D. J. 1961. Spore studies in the genus Cystopteris. I. The distribution of Cystopteris with non-spiny spores in North America. Rhodora **63**: 181–193.

[3] Larsen, K. 1952. Udbredelsen i Grönland af Cystopteris fragilis coll. med piggede og vortede sporer. Bot. Tidsskr. **49**: 39–44.

Notes and News

A NEW NEWSLETTER.—To better promote communication and the exchange of materials between our members, the American Fern Society is inaugurating a quarterly Newsletter. Prof. James Montgomery, an enthusiastic student of North American ferns and a frequent participant in our Fern Forays, and Mr. F. Gordon Foster, an experienced horticulturist and author of "The Gardener's Fern Book," will be in charge of the Newsletter. Non-technical items and notes of passing interest will be most welcome. The officer's reports and a membership list will appear in the Newsletter each year. We hope especially that our members who are naturalists and gardeners will contribute to the Newsletter and will find it interesting and informative.

GEORGE NEVILLE JONES, Professor of Botany and Curator of the Herbarium at the University of Illinois, died last June 25. He had been a Fern Society member for a quarter of a century. He was the author of many monographs and floras, including "A Botanical Survey of the Olympic Peninsula" and "Flora of Illinois." His principal work on ferns, "An Annotated Bibliography of Mexican Ferns," was published four years ago.

PLANTS OF ASPLENIUM EBENOIDES × CAMPTOSORUS RHIZOPHYLLUS are available to persons interested in growing this backcross hybrid Spleenwort. Please request living specimens. Scott's Spleenwort, *A.* × *ebenoides*, is the hybrid of the Ebony Spleenwort, *A. platyneuron*, and the Walking Fern, *Camptosorus*. We have available numerous proliferations of the backcross of the hybrid to the walking-fern, which was originally made by Mrs. Kathryn E. Boydston at Fernwood, Niles, Michigan. This backcross plant has proved to be extremely vigorous in culture. It looks like a somewhat lobed Walking Fern with a dark stipe, and it grows in a graceful, spreading manner. It should be grown in a Wardian case or terrarium in ordinary potting soil.—W. H. WAGNER, JR., *Matthaei Botanical Gardens, University of Michigan, Ann Arbor, Mich. 48104.*

EDWARD M. SHIELDS, 1895–1970.—Members of the American Fern Society, especially those who some years ago participated in its field trip in eastern New York, will regret to learn of the death from a heart attack on September 17th of "Eddie" Shields, who on the occasion of the field trip entertained us at the summer residence he then maintained at Haines Falls in the Catskills.

As a youth Eddie roamed his native Chester County, Pennsylvania, collecting at first minerals and Indian relics. Receiving from the family real estate holdings there sufficient income to live comfortably, he became an amateur naturalist of wide interests. On a field trip in Florida he made some notable orchid finds, thereby becoming acquainted with Oakes Ames, the specialist on these plants. His interest in ferns was aroused when, on a visit to Cambridge, Ames introduced him to Charles A. Weatherby. Exploring the Haines Falls region for ferns, he discovered a remarkable southern disjunct outlier of the Fragrant Fern, *Dryopteris fragrans*.

After some years, Eddie came to spend his whole time in Sarasota, Florida. Studying subtropical horticulture, he developed around his house a garden including many uncommonly used yet highly attractive plants. In an adjoining slat-house, which after a couple of disastrous freezes evolved into a greenhouse, he specialized on growing unusual orchids. He would stop in at one of the many Florida orchid-sales places, and with his keen eye and thorough acquaintance with current literature, would often detect as a rarity a plant offered as a common one.

Ferns in his garden greenhouse were merely incidental; in the living room he had a spectacular hanging-basket culture of Narrow Strap-fern (*Campyloneuron angustifolium*). His fern books and herbarium were given to the West Chester, Pennsylvania, State College.

Eddie is survived by his wife "Jerry" and by several children and stepchildren. Memories of his cordiality and generosity to me over the years have made this note most difficult for me to write. —EDGAR T. WHERRY, *Leidy Laboratory, University of Pennsylvania, Philadelphia, Pa. 19104.*

Recent Fern Literature

PACIFIC NORTHWEST FERNS AND THEIR ALLIES, by T. M. C. Taylor. University of Toronto Press, 33 East Tupper St., Buffalo, N. Y. 14203. 1970. 247 pp., illustr. $15.00.—This is the first full-fledged local fern flora to appear in several years. The area covered includes that treated recently in the "Vascular Plants of the Pacific Northwest" (reviewed in this JOURNAL. **60**: 34–38. 1970), but is more extensive, since all of British Columbia, the Yukon Territory, and all of Alaska is included. The number of species treated is 97, about a quarter of all those known from North America north of Mexico. Many of these are boreal plants familiar in the eastern United States and Canada and many occur also in Eurasia. Twenty-seven are western American endemics (but not local endemics, except for *Botrychium pumicola*, confined to the region of Crater Lake, Oregon). The species all have full descriptions and most of them have distribution maps and line drawings. The latter are very good, so good that most species can be easily recognized from the drawings alone. (I would except the drawing of *Polystichum scopulinum*, which shows a plant not typical of this species and which might even represent *P. kruckebergii* instead.) The systematic treatment is commendably conservative. The comments indicate the variations found and some of the taxonomic problems still unsolved. There are few errors indeed, and the comments below are of strictly minor importance.

The authority of *Blechnum spicant* is not "J. Sm." but Roth (cf. this Journal **34**: 51. 1944); incidentally, it is usual to use "J. Sm." for John Smith; the author intended here was not John Smith but Sir James Edward Smith, usually cited as J. E. Smith, for the abbreviation of Smith to "Sm." is really not sanctioned by the Code. The work in which *Dryopteris* was published by Adanson is not "Farn Pl." but "Fam. Pl." In the description, the sori of *Polypodium montense* are said to be "submarginal," but in the drawing they are shown as about medial (for a comment on the name "*montense*" see this JOURNAL **60:** 126–7. 1970). *Polypodium virginianum* is described as having the segments "linear-oblong to

lanceolate . . . obtuse at apex," which is essentially correct, although the apex does vary from rounded to acute, but in the comments it is said to be distinguishable from *P. montense* by the segments being "narrowly ovate with acute tips," which is not true and which contradicts not only the description but also the drawing, which shows the segments as oblong and rounded at apex. In the synonymy of *Thelypteris nevadensis*, the first line ought really to be "ex Morton, Amer. Fern J. **48**: 139. 1958," as required by the Code; otherwise it appears that Clute published the name some eight years after his death. The *Azolla* of the area is referred to *A. mexicana*, following Svenson; the report of *A. filiculoides* from Alaska by Svenson is rejected with the statement "almost certainly an aquarium escape," which is perhaps an unwarranted assumption, since the specimen was collected in 1868, an early period in the history of Alaska when aquaria must have been essentially unknown; still, the record must be considered doubtful since no other Alaskan material has ever turned up. There are specimens in the U. S. National Herbarium from Oregon and Washington that have been identified as *A. filiculoides* (and subsequently to Svenson's treatment), but they are sterile, I believe, and so somewhat doubtful. An effort should be made to collect fertile material from these states. Possibly Svenson overstressed the character of the septae in the glochidia, and his treatment has never been critically evaluated. Although it is irrelevant here, I might mention that although Svenson indicated that *A. caroliniana* must spread solely by vegetative means, since megaspores are never found in American material, some recent European workers have described the megaspores of this species, considered introduced in Europe. It is possible that the European plants so identified are not really *A. caroliniana*, and the matter should be investigated. It is rather too bad that this book perpetuates the spellings "*sabinaefolium*," "*matricariaefolium*," and "*andromedaefolia*"; although these were the original spellings, Art. 73, Note 2, says that the use of a wrong connecting vowel is to be treated as an orthographic error, and Art. 73 itself indicates that orthographic errors are to be corrected; thus the correct spellings are "*sabini-*

folium," "*matricariifolium*," and "*andromedifolia*." One feature, which does not at all detract from the book but which is sufficiently peculiar to deserve mention, is the placing of *Selaginella* at the end, following the Polypodiaceae, instead of at the beginning, with *Lycopodium*, *Isoëtes*, *Equisetum*, and other fern allies.—C.V.M.

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Errata

Page 105, line 3: For "*B. araucana*" read "*B. araucanum.*"
Page 125, line 8: For "*A. auriculata*" read "*S. auriculata.*"
Page 127, line 8: For "*1166*" read "*11667.*"

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A QUARTERLY DEVOTED TO FERNS

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AMERICAN FERN SOCIETY

EDITORS

DAVID B. LELLINGER

C. V. MORTON ROLLA M. TRYON

IRA L. WIGGINS

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American Fern Journal

VOL. 71 [61] JANUARY–MARCH, 1971 NO. 1

A Study of Azolla pinnata R. Brown

A. SWEET AND L. V. HILLS[1]

A study was undertaken to ascertain the morphologic variability of the vegetative and fruiting structures of plants within the *Azolla pinnata* complex. Plants of this group have been commonly referred to three species, *A. pinnata*, *A. africana*, and *A. imbricata*. Our observations indicate that only one species is present, although two varieties based on vegetative morphology can be established. The synonymy given by Christensen (1905, p. 148) forms the basis of our synonymy for *A. pinnata*. In addition to Christensen, the original diagnoses and the work of Baker (1887) and Shen (1961) were consulted in working out the taxonomy of this group. Anatomical studies have been done on these plants by Griffith (1845), Strasburger (1873), Sud (1934), Rao (1936), Delmalsy (1958), and Bonnet (1957). Moore (1969) gives a general review of the literature on *Azolla* and indicates its use in agriculture.

A total of 85 collections were examined, 70 in detail. When available, at least 10 plants per collection were examined under a binocular microscope. Wetting was sometimes used to bring out detail. Massulae were placed in water under a vacuum for two hours to remove air bubbles. Following this, they were mounted in polyvinyl alcohol (Elvanol solution) on a cover slip which, when dry, was affixed to a slide with Canada balsam. The megaspore complexes were treated with acetolysis solution for 5–10 minutes at 200°F, washed, and then oxidized with Shultze solution (HNO_3

[1] The authors would like to acknowledge the co-operation of herbaria that contributed to this study by lending their collections. Scanning electron photos were taken by Mr. J. Bloor. Mr. L. Johnson helped with the photography and Mr. P. Wolters with the drafting. The manuscript was typed by Miss N. Fraser. Expenses were covered by a National Research Council Grant-in-Aid of Research to L. V. H.

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+ $KClO_3$). Mounting followed the same procedure as with the massulae.

TERMINOLOGY

The definition of new terms and terms which have been used as applied to *Azolla* in conflicting ways are as follows:

Trichomes.—The spine-like projections arising from the angles between the contact areas on the proximal surface of the massulae, having vacuoles continuous with those of the massulae (Shen, 1961). The restriction of trichomes to the proximal surface and the distribution of vacuoles differentiates trichomes from glochidia which occur in the species of section *Azolla*.

Megaspore complex.—The composite structure from which the female gametophyte develops.

Cap.—The remnant of the indusium persisting as a total or partial covering over the floats (*Figs. 1, 2*).

Supraspore (new term).—The apical region of the megaspore complex (*Fig. 1*) consisting of: The columella or apical extension of the perine forming a central conical projection (*Fig. 6*); the columnar filaments or fibrils arising from the apex of the columella and spreading over the surface of the upper floats; and the floats (*Figs. 1, 2*).

Collar.—The region intermediate between the supraspore and the infraspore formed by a thickening of the perine.

Infraspore (new term).—The distal area of the megaspore complex (*Fig. 1*) consisting of the exine or wall of the megaspore or germinal body (*Figs. 3, 5, 20*); and the perine or wall layer formed exterior to and free from the exine (*Figs. 1, 2*).

Inperine (new term).—The inner, homogeneous or vacuolate zone of the perine located adjacent to the exine (*Figs. 5, 20*).

Experine (new term).—The outer, sculptured zone of the perine.

Experine 1 (new term).—The inner zone of the experine with a vacuolate or pillar-like character which acts as a foot layer for the outer elements of sculpturing (*Figs. 5, 20*).

Experine 2 (new term).—The outer zone of the experine composed of the larger elements of sculpturing (*Figs. 5, 20*).

The subdivision given for the infraspore agrees in principle with that of Strasburger (1873), Rao (1936), Delmalsy (1958), Bonnet (1957), Kempf (1969) and Snead (1969), but differs from that of Hall (1968), who considers only the outer fibrous layer found on some fossil forms of *Azolla* to be perisporial material. He includes our experine and inperine as part of the megaspore exine.

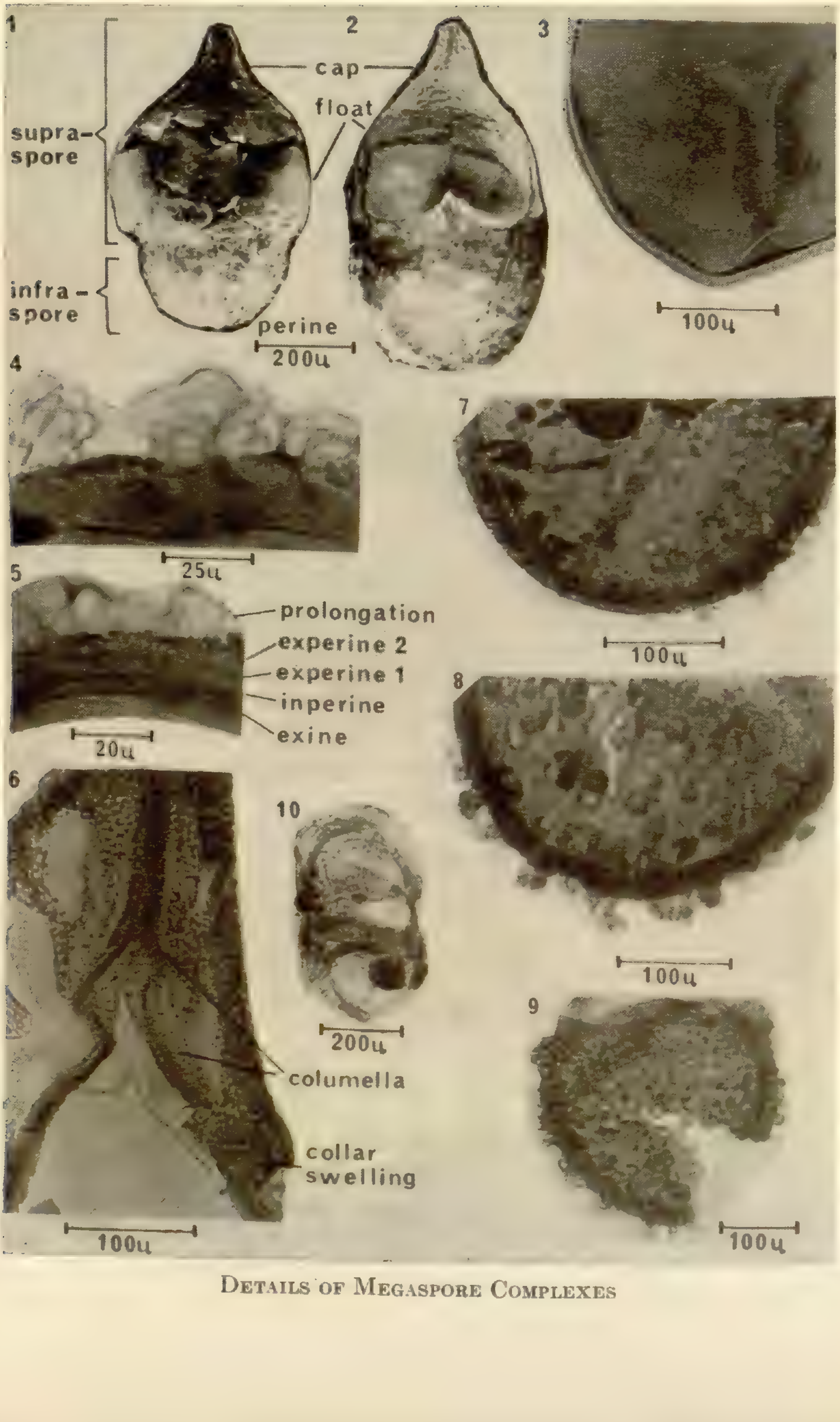
AZOLLA PINNATA R. Brown, Prodr. Fl. Nov. Holl. 167. 1810.

Plants small, floating aquatics with bilobed leaves. Pubescence prominent on upper surface of dorsal leaf lobe and on stem near leaf base, sometimes extending over entire internodal area, and less commonly onto margin of ventral leaf lobe. Ventral leaf lobes (*Fig. 15*) composed of single layer of cells, 1.5–2 times larger than dorsal leaf lobes. Two or more leaves before first lateral branch, then one leaf between succeeding branches (*Fig. 25*).

Megaspore complex 425–660 μ (avg. 560 μ) long. Caps 200–250 μ long, ½–⅔ projecting above supraspore (*Figs. 1, 2*). Generally 9 floats symmetrically arranged in groups of 3; each group containing 1 diamond-shaped upper float 1.5–2 times the size of the 2 trapezoidal lower floats (*Fig. 21*). Sometimes one extra small lower float (*Figs. 1, 2*). Upper floats covered by columnar fllaments. Inperine and experine apparent in columella (*Fig. 6*). Expansion of inperine at top of infraspore forming indistinct collar (*Fig. 6*).

Infraspore 225–450 μ (avg. 310 μ) wide, composing ½–⅓ of megaspore complex. Trilete rays ¼ length of megaspore radius; exine perforate, 7 μ thick (*Fig. 3*). Perine 16 μ thick with homogeneous inperine 6 μ thick (*Figs. 5, 20*); experine 1 of irregular pillar-like structures, 1–2 μ thick (*Fig. 20*); and experine 2 of irregular branching and fusing baculae 2–5 μ in diameter, 8–9 μ thick (*Figs. 5, 20*). Projecting from experine, convoluted prolongations 12–14 μ long, consisting of a hollow central cylinder 10–30 μ in diameter arising from inperine to which are fused swollen baculae (*Figs. 4, 20*). Prolongation density variable (*Figs. 7–9*). Surface filaments rare or lacking.

Microsporangia containing 3–8 massulae each having a convex distal and a pyramidal proximal surface (*Fig. 13*). Massulae 135–210 μ (avg. 190 μ) long, 150 μ wide, and 100 μ deep. Trichomes 2–10, usually 4–5 in number, 45–150 μ long, 4–20 μ wide at base; varying in shape from threadlike to stocky (*Figs. 11, 13*). Spines, structurally resembling short trichomes, up to 20 μ long at the corners of some massulae (*Fig. 11*) or less frequently around the entire equatorial margin (*Fig. 12*). Massulae surface granular or finely vacuolate. Microspores 18 μ in diameter.



Details of Megaspore Complexes

PROBABLE ISOSYNTYPES: Iter Australiense, 1802–05, *R. Brown 134, 135* (Presented by direction of J. J. Bennett, 1876) (E!).

RANGE: As in *Plate 4*, see also p. 7).

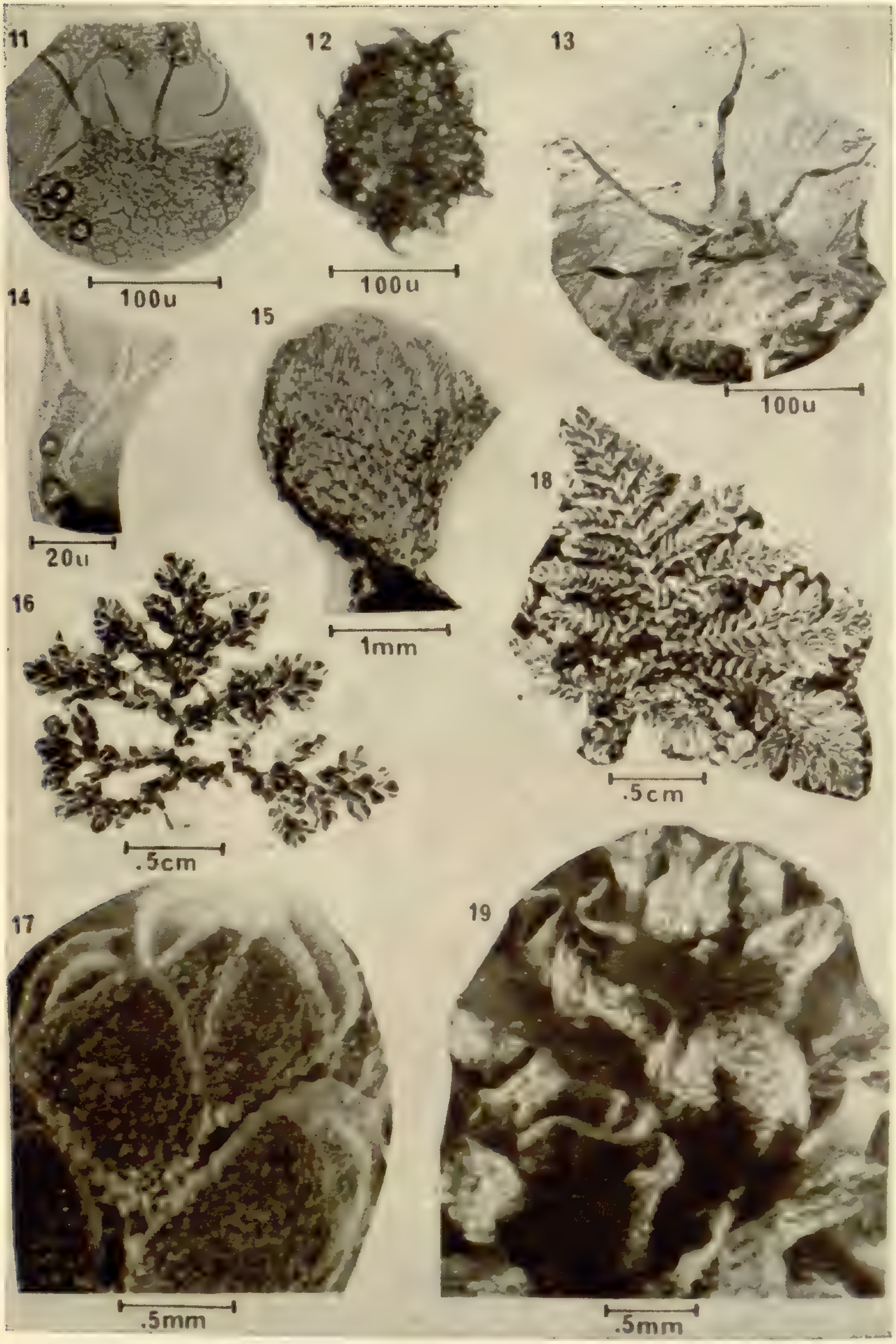
The size of the megaspore complex and component structures was found to be relatively constant within individual collections, but the total inter-collection variability was large. In particular, megaspores complexes from Africa were notably larger (avg. 600 μ) than those from other regions (avg. 475 μ). As this size difference was not correlated with any distinctive structural features either within the megaspore complex or other plant parts, we believe it best not to use it to establish a distinct taxonomic group. Inter-collection variation in the density of the prolongations occurred randomly with respect to geographic distribution; therefore, it is not taxonomically useful.

In 5–10 % of the specimens one additional float appears either by division of one of the lower floats (*Figs. 2, 22*), or as an extra small float at the base of the supraspore either between two floats (*Fig. 23*), or below and partially replacing one float (*Figs. 1, 24*). The occurrence of floats supplementary to the basic number of nine may be used in attempts to work out the phylogeny of *Azolla* (see Hills and Gopal, 1967). One double megaspore complex was observed (*Fig. 10*) where two infraspores were fused together, the supraspores being absent (see also Strasburger, 1893, *Fig. 100*).

The greatest development of spines on massulae was seen on specimens from Africa. Specimens from Australia and New Guinea had spines only at the corners of lenticular-shaped massulae. Although not all massulae from Africa, Australia and New Guinea had spines, this was the only morphologic variation which correlated in part with specific plant types. In the future this feature

---

FIG. 1. SCANNING ELECTRON PHOTOS OF MEGASPORE COMPLEXES WITH SUPPLEMENTARY LOWER FLOAT. FIG. 2. SAME, DIVIDED LOWER FLOAT. FIG. 3. MEGASPORE WITH PERFORATE EXINE AND TRILETE MARK. FIG. 4. ENLARGEMENT OF CONVOLUTED PROLONGATIONS. FIG. 5. WALL CROSS-SECTION. FIG. 6. LONGITUDINAL SECTION OF MEGASPORE COMPLEX. FIGS. 7–9. ENLARGEMENTS OF INFRASPORES ILLUSTRATING VARIATION IN PROLONGATION DENSITY. FIG. 10. FUSED INFRASPORES.



Details of Massulae and Leaves

should be noted, as it may be diagnostic.

Branched trichomes (*Fig. 14*) were observed by Rao (1936). The abundance of branching is variable, occurring in about 10% of the trichomes. Within the same collection or even in massulae from the same microsporangia some massulae have branched trichomes, whereas others lack them; hence the presence or absence of branched trichomes is not a reliable taxonomic character.

Morphologic variability in the fruiting structures cannot be used to subdivide *A. pinnata* into varieties. However, on the basis of leaf-branch morphology two varieties can be recognized.

AZOLLA PINNATA R. Brown var. PINNATA

Azolla africana Desv. Ann. Soc. Linn. Paris **6**: 270. 1827.

Azolla guineensis Schum. Beskrivelse af Guineiske planter. 462. 1827 [a preprint]. See also Dansk Vid. Selsk. Skr. Natur. Mat. Afhandl. **4**: 236. 1829.

Azolla pinnata var. *africana* (Desv.) Baker, Handb. Fern Allies. 138. 1887.

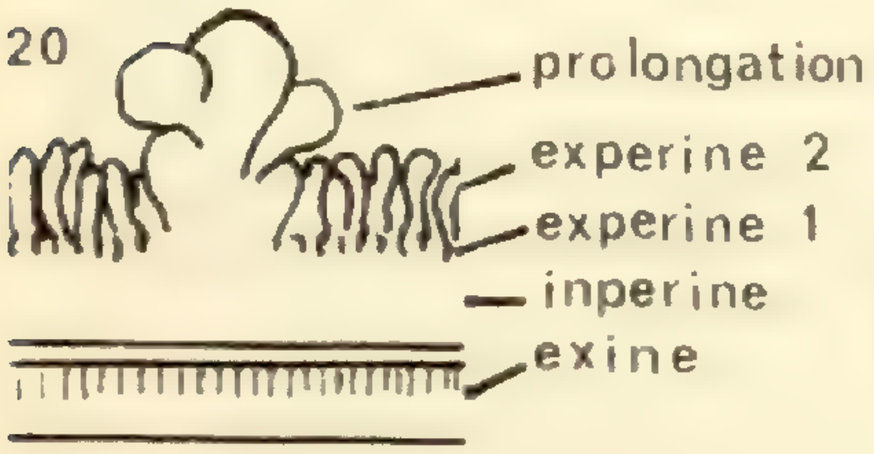
Plants 1.5–2.5 cm long, 1–1.5 cm wide, with dominant main axis and pinnate appearance (*Fig. 18*). Dorsal leaf lobes 0.8–1.9 mm long, 0.5–1.10 mm wide, length-width ratio 1.4–2.1, imbricate to highly imbricate (may be non-imbricate), relatively thick, curled both longitudinally and transversely, elongate, acute at the apex, with a hyaline margin of irregular width formed by up to four rows of elongate cells, the tips protruding to give a serrated margin (*Fig. 19*). Echinate pubescence on basal portion of dorsal leaf lobe grading to sometimes dense, irregularly arranged, conical pubescence on upper part, this sometimes accompanied by longitudinal striations. Leaves 4–16 (avg. 8) before the first branch.

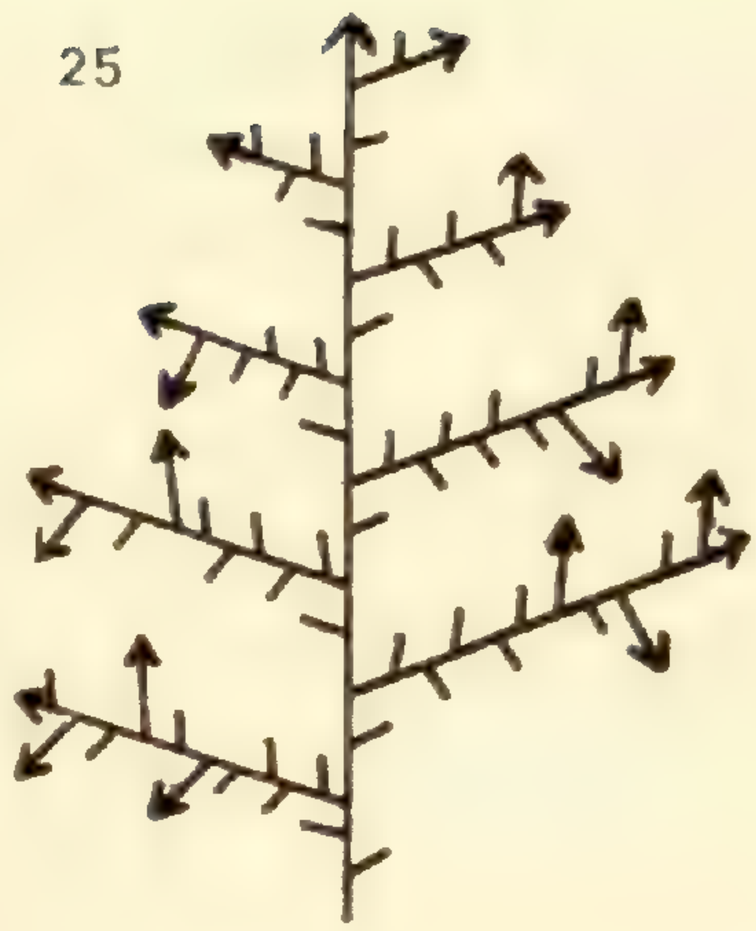
RANGE: Australia, New Guinea, Africa and Madagascar. Collection 30 (*Pl. 4*) from Thailand is most similar to plants from New Guinea and may represent a population introduced for agricultural purposes; otherwise it is disjunct in its occurrence).

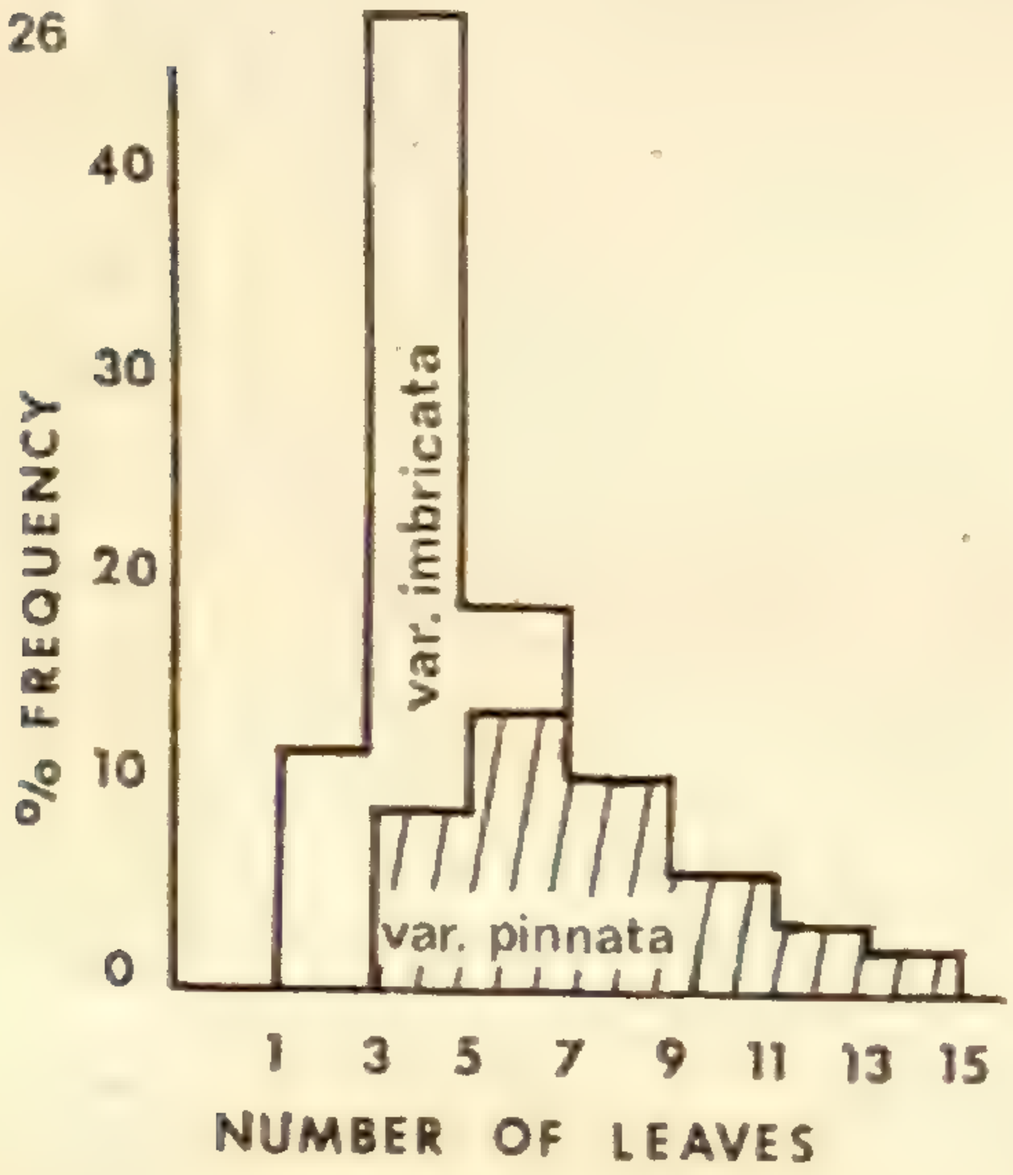
COLLECTIONS SEEN: See page *11* and *Plate 4*.

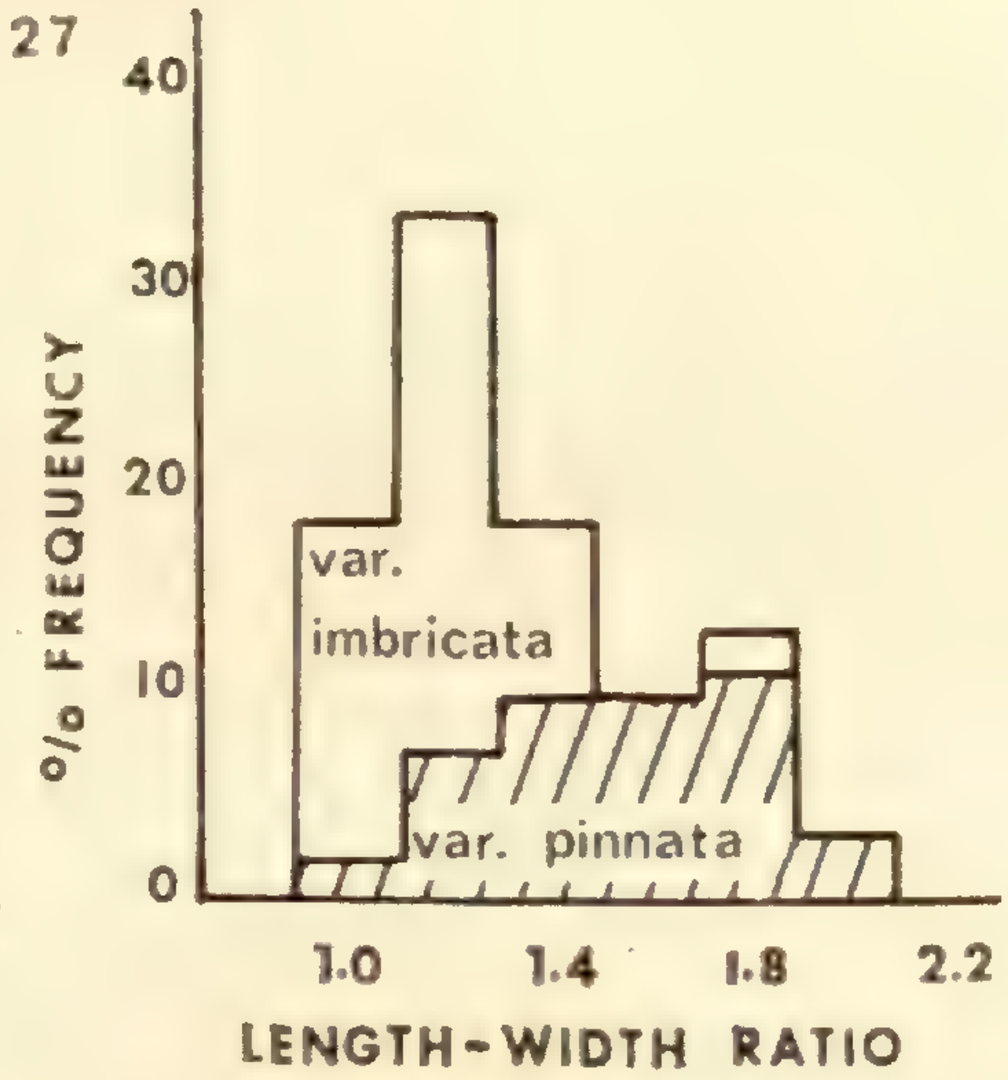
AZOLLA PINNATA var. IMBRICATA (Roxb.) Bonap. Notes Pterid. **7**: 130. 1918.

FIG. 11. EQUATORIAL VIEW OF MASSULAE SHOWING END SPINES, TRICHOMES AND MICROSPORES. FIG. 12. DISTAL VIEW OF MASSULAE WITH EQUATORIAL SPINES. FIG. 13. S.E.M. PHOTO OF OBLIQUE PROXIMAL VIEW OF MASSULAE. FIG. 14. TRICHOME WITH BIFURCATED TIP. FIG. 15. VENTRAL LEAF LOBE. FIG. 16. PLANT OF VAR. IMBRICATA. FIG. 17. DORSAL LEAF LOBES OF VAR. IMBRICATA. FIG. 18. PLANT OF VAR. PINNATA. FIG. 19. DORSAL LEAF LOBES OF VAR. PINNATA.









MORPHOLOGY AND DISTRIBUTION OF A. PINNATA.

FIG. 20. SCHEMATIC DIAGRAM OF MEGASPORE COMPLEX WALL MORPHOLOGY. FIG. 21. RELATIVE SIZE AND SHAPE OF FLOATS. FIG. 22. LEFT LOWER FLOAT DIVIDED. FIG. 23. ADDITIONAL FLOAT BETWEEN PAIR OF LOWER FLOATS. FIG. 24. ADDITIONAL FLOAT BELOW ONE LOWER FLOAT. FIG. 25. SCHEMATIC REPRESENTATION OF LEAF-BRANCH PATTERN. FIG. 26. DISTRIBUTION OF THE NUMBER OF LEAVES BEFORE THE FIRST LATERAL BRANCH. FIG. 27. DISTRIBUTION OF THE LEAF LENGTH-WIDTH RATIOS.

Salvinia imbricata Roxb. ex. Griff. Calcutta J. Nat. Hist. **4:** 469. 1844.

Azolla imbricata (Roxb.) Nakai, Bot. Mag. Tokyo **39:** 185. 1925.

Plants 1–1.5 cm diameter. Main stem not dominant, but with dichotomous-like type of branching (*Fig. 16*). Dorsal leaf lobes 0.8–1.5 mm long, 0.6–1.0 mm wide, length-width ratio 1.1–1.5, generally non-imbricate to slightly imbricate, thin, flat, ovate to trapezoidal, rounded to subrounded at the apex, with a hyaline margin of regular width formed by 2–5 rows of nearly equidimensional cells (*Fig. 17*). Echinate pubescence on basal portion of dorsal leaf lobe grading to evenly distributed conical pubescence on the upper part (*Fig. 17*). Leaves 2–8 (avg. 4–5) before the first lateral branch.

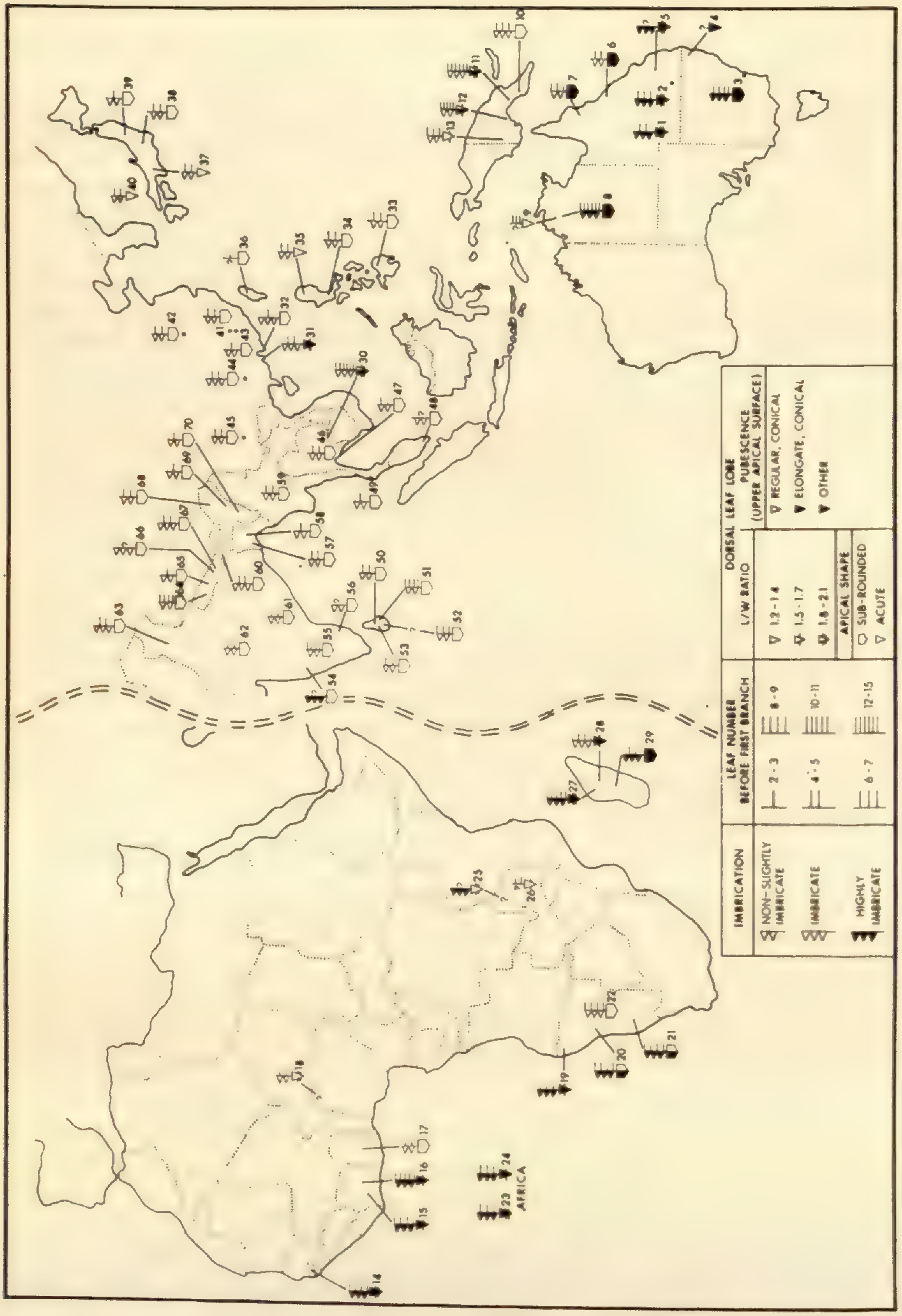
RANGE: India, Nepal, Ceylon, Burma, Southeast Asia, Philippines, China, and Japan; one disjunct collection from Africa. Plants intermediate between var. *pinnata* and var. *imbricata* are found in Australia, New Guinea, Africa and India.

COLLECTIONS SEEN: See page *11* and *Plate 4*.

Azolla pinnata var. *imbricata* is distinguished by the plants being generally smaller and more circular in shape, with rounded to subrounded, ovate to trapezoidal dorsal leaf lobes, these with a regular hyaline margin of nearly equidimensional cells and regularly distributed conical pubescence.

The trivial name *imbricata* was an unfortunate choice by Roxburgh (1844), who compared them with the non-imbricate *Salvinia*. To him the *Azolla* would seem imbricate, as the ventral leaf lobes are overlapping and the dorsal leaf lobes are never widely spaced. However, we have found these plants to be non-imbricate compared to those of var. *pinnata*.

The distinctiveness of the leaf-branch pattern in different species of *Azolla* was first suggested by Strasburger (1873). Bonnet (1957) states that in *A. pinnata* 3–9 leaves precede the first branch and the number of leaves before the first lateral branch increases toward the apex of the plant. We observed 2–16 leaves and no consistent increase or decrease towards the apex. *Figure 26* shows the distribution of average leaf numbers before the first branch, based on at least 10 counts per collection. Although in general



Characters and Geographic Distribution

fewer leaves occur before the first branch in var. *imbricata* than in var. *pinnata*, leaf-branch pattern is a more useful criterion for separating species of *Azolla* (Bonnet, 1957) than for separating varieties within *A. pinnata*.

Figure 27 shows the distribution of length-width ratio for the dorsal leaf lobes, based on at least five mature specimens per collection. This ratio, if considered in conjunction with other criteria, is useful in distinguishing the two varieties.

The leaf-branch pattern, the apical shape, the degree of imbrication, the type of pubescence, and the length-width ratio of the dorsal leaf lobe are symbolically represented with respect to geographical distribution in *Plate 4*. In the preceding descriptions and in *Plate 4* the term "non-imbricate" describes leaves in which there is no overlap; "highly imbricate" when they overlap for at least 2/3 of their length, and "imbricate" when the overlap is intermediate. "Regular conical" indicates evenly distributed pubescence whose length is less than twice the width and "elongate conical" indicates irregularly distributed conical pubescence accompanied by longitudinal striations.

The numbers in *Plate 4* refer to the following collections:

Var. PINNATA: 1, *R. Brown 134* (E); 2, *R. Brown 135* (E); 4, *S. Helms 413* (C); 5, *M. Clemens 1947* (OSC); 9, *Baron Von Mueller* (CAL); 11, *R. Schodde 2673* (US); 12, *L. Brass 5843* (C); 13, *A. Harre 270* (F); 14, *J. Brown-Lester* in 1890–1891 (CAL, E); 15, *H. des Abbayes 2251* (US); 16, *H. des Abbayes 2252* (US); 18, *O. Hagerup 751* (C); 19, *H. Baum 105* (M, E); 20, *A. Peter 35683* (UC); 21, *A. Peter 44388* (UC); 23, *R. Schlechter 12033* (M); 24, *H. Soyaux*, 24/11/1874 (M); 25, *H. M. Richards 8313;* 26, *R. B. Drummond & A. J. Cookson 6272*; 27, *J. M. Hildebrandt 3065* (M); 28, *G. F. S. Elliot 1798* (E); 30, *Th. Sorensen, K. Larsen & B. Hansen 547* (C). Examined but not plotted: *N. H. W. Brown* (E), *Gower Collection*, River Quenso (E).

Var. IMBRICATA: 17, *P. Cadjoe 983* (M); 32, *Em. Bodinier 1427* (E); 33, *M. S. Clemens*, 3/1907 (M); 34, *A. Loher 1149* (M, US); 35, *H. M. Curran 11624* (C); 36, *A. M. Evans 540* (TENN); 37, *G. Murata 27129* (US); 38, *Siebold?* in 1842 (M); 39, *T. Nakano* in 6/1896; 40, *M. Hutch 17883* (E); 41, *L. H. Bailey* in 7/27/1917 (US); 42, *A. Henry 3977* (CAL); 43, *H. C. Cheo 501* (E); 44, *Kweichow Expedition 4220* (C); 45, *H. Smith 1518* (C); 46, *Th. Sorensen, K. Larsen & B. Hansen 1829* (C); 47, *Urupai* on 2/21/1969; 48, *J. Sinclair* on 12/12/1948 (E); 49, *J. Sinclair* on 14/11/1950 (E); 50, *Ferguson* (M); 51, *Thwaites C. P.* [Ceylon Plants] *1421* (E); 52, *Marshall Ward*

in 10/1880 (E); 53, *A. O. Brodie* in 9/186? (E); 55, *C. E. C. Fischer 4027* (CAL); 56, *Dr. Wight* in 1831 (E); 57, *Shaik Mo Kim* in 1896 (CAL); 58, *P. M. Debbarman 644* (CAL); 59, *S. Kurz 3194* (CAL); 60, *J. D. H.* (C); 61, *J. J. Wood 187* (CAL); 62, *C. Maries 1890* (CAL); 63, *H.H. Johnston* on 1/27/1896 (E); 64, *O. Polunin, W. R. Sykes & L. H. J. Williams, 1822* (E); 65, *Stainton, Sykes & Williams 6952* (E); 66, *D. H. Nicolson 2911* (US); 67, *Stainton, Sykes & Williams 2546* (CAL, E); 68, East India, *Dr. Wight* (E); 69, *H. Collett*, 11/1890 (CAL); 70, *G. Watt 5090* (CAL). Examined but not plotted: *M. Vanoverbergh 3226* (BKL); *R. R. Stewart 1359* (BKL); *Gower Collection* (E); *Wight 5* (C).

INTERMEDIATE TYPES: 3, *J. Camfield* in 4/1897 (US); 6, *N. Michael 1431* (E); 7, *W. Layer* (M); 8, *R. Specht 1166* (US); 10, *P. Darbyshire 803* (US); 22, *H. Merxmuller & W. Guiess* on 8/03/1958 (M); 29, *J. M. Hildebrandt 3595* (M); 31, *G. H. Vachell* on 17/7/1830 (E); 54, *Stocks, Law* (C).

The distribution of the two varieties presents an interesting problem. The close similarity of the disjunct populations of var. *pinnata* indicates the populations were once connected. Megaspore complexes similar to those of *A. pinnata* in Upper Pliocene-Lower Pleistocene strata of Russia (Nikitin, 1957; Dorofeve, 1963) indicate the species was once much more widespread. It is therefore reasonable to assume that the separation of populations of var. *pinnata* may have occurred as the result of glaciation during the Pleistocene (ca. last 3 million years).

Plants typical of var. *pinnata* were not seen in collections from India and Ceylon. However, some plants from these regions had notably higher leaf numbers before the first branch than usual is for var. *imbricata*. Other plants had pubescence more like that of var. *pinnata*. This may suggest a former relic population of var. *pinnata* in India and/or Ceylon which has influenced the character of, and has been absorbed into, the present population.

Attempts were made to relate the distribution of the two varieties to generalized plots of variations in temperature and light intensity. No direct relationship between these factors and the distribution pattern was found. It was noted that var. *imbricata* occurs in more densely populated areas, suggesting that some agricultural practice may influence the distribution. However, the succession of plants from Australia to Southeast Asia appears to reflect a clinal development, and therefore agriculture is probably not the controlling factor.

Future paleobotanic studies will unquestionably add to our knowledge of the former distribution of the species. The answer to the relationship between the two varieties and the reasons for the distinct geographic ranges will best be answered by the study of the varieties themselves. Future collections should be more specific as to the character of the collecting site and its ecological setting.

LITERATURE CITED

BAKER, J. G. 1887. Handbook of the fern allies. George Bell, London.

BONNET, A. L. M. 1957. Contribution à l'étude des Hydoptéridées. III. Recherches sur Azolla filiculoides Lamk. Rev. Cytol. Biol. Végét. **18**: 1–88.

CHRISTENSEN, C. 1905–6. Index Filicum. Hagerup, Copenhagen.

DELMALSY, P. 1958. Nouvelles recherches sur le sporophyte d'Azolla. La Cellule **59**: 235–268.

DOROFEEV, P. I. 1963. The Tertiary floras of Western Siberia. Akad. Nauk SSSR, Bot. Inst. Komarov, Leningrad.

GRIFFITH, W. 1845. On Azolla and Salvinia. Calcutta J. Nat. Hist. **5**: 227–273.

HALL, J. W. and N. P. SWANSON 1968. Studies of fossil Azolla: Azolla montana, a Cretaceous megaspore with many small floats. Amer. J. Bot. **55**: 1055–1061.

HILLS, L. V. and B. GOPAL. 1967. Azolla primaeva and its phylogenetic significance. Canad. J. Bot. **45**: 1179–1191.

KEMPF, E. K. 1969. Elektronenmikroskopie der Sporodermis von känozoischen Megasporen der Wasserfarn-Gattung Azolla. Paläont. Zeitschr. **43**: 95–108.

MOORE, A. W. 1969. Azolla: Biology and agronomic significance. Bot. Rev. **35**: 17–34.

NIKITIN, P. A. 1957. Pliocene and Quaternary floras from Voronezh District. Acad. Nauk SSSR, Bot. Inst., Moscow–Leningrad.

RAO, H. S. 1936. The structure and life history of Azolla pinnata. R. Br. with remarks on the fossil history of the Hydropterideae. Proc. Indian Acad. Sci. **2**: 175–200.

SHEN, E. Y. F. 1961. Concerning Azolla imbricata. Amer. Fern J. **51**: 151–155.

SNEAD, R. G. 1969. Microfloral diagnosis of the Cretaceous-Tertiary boundary, Central Alberta. Res. Coun. Alberta Bull. 25.

STRASBURGER, E. 1873. Ueber Azolla. Friedrich von Zezschwitz, Jena.

SUD, S. R. 1934. A preliminary note on the study of Azolla pinnata R. Br. J. Indian Bot. Soc. **13**: 189–197.

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A New Variety of Lindsaea odorata Roxb. from Darjeeling in the Himalayas

T. SEN AND U. SEN[1]

During our field studies in Darjeeling in 1965 and 1967, we discovered some *Lindsaea* specimens that were strikingly different from the species of *Lindsaea* familiar to us. The plants resemble *Lindsaea odorata* Roxb.,[2] which is also found in Darjeeling. However, close examination showed that they are quite distinct: they are smaller and have short branched foliar hairs, but lack multicellular long hairs and internal endodermis in the rhizome. These plants thus represent an undescribed taxon.

LINDSAEA ODORATA var. **darjeelingensis** Sen & Sen, var. nov.

A var. *odorata* differt: frondibus multo minoribus, usque ad 15 cm longis et 1.7 cm latis; paleis rhizomatis latitudine basi ex cellulis 4–7 constantibus; frondibus juvenilibus pilis brevibus ramosis praeditis; endodermide interiore stelis rhizomatis carente.

Rhizome creeping, short, slender, ca 2 mm in diameter; scales deep brown, acuminate, up to 7 cells broad at the base; vascular cylinder an amphiphloic solenostele but lacking an internal endodermis. Fronds simply pinnate, to ca 15 cm long, 1.7 cm wide; petiole slender, shallowly grooved on the adaxial surface, round below, to 4 cm long. Pinnae usually distinctly spaced, short-stalked (0.5 mm), 3-lobed, the basiscopic margin convex, the inner margin straight; veins immersed, the main vein along the basiscopic margin bearing 3 or 4 branches, each 1- or 2-forked, 1–4 veins ending at the margin of each lobe; laminae of young fronds with small, 2- or 3-celled, unbranched, glandular hairs and 3-celled branched glandular hairs; sporangia globose; annulus of 15–25 cells; stomium 8–12 cells; paraphyses present with sporangia; spores bilateral, 52 μ × 38 μ × 33 μ, enclosed by a thin perine, this cracking off on acetolysis.

TYPE: Darjeeling, on way to Birch Hill, *Sen & Sen 505* (holotype, Department of Botany, University of Kalyani, West Bengal).

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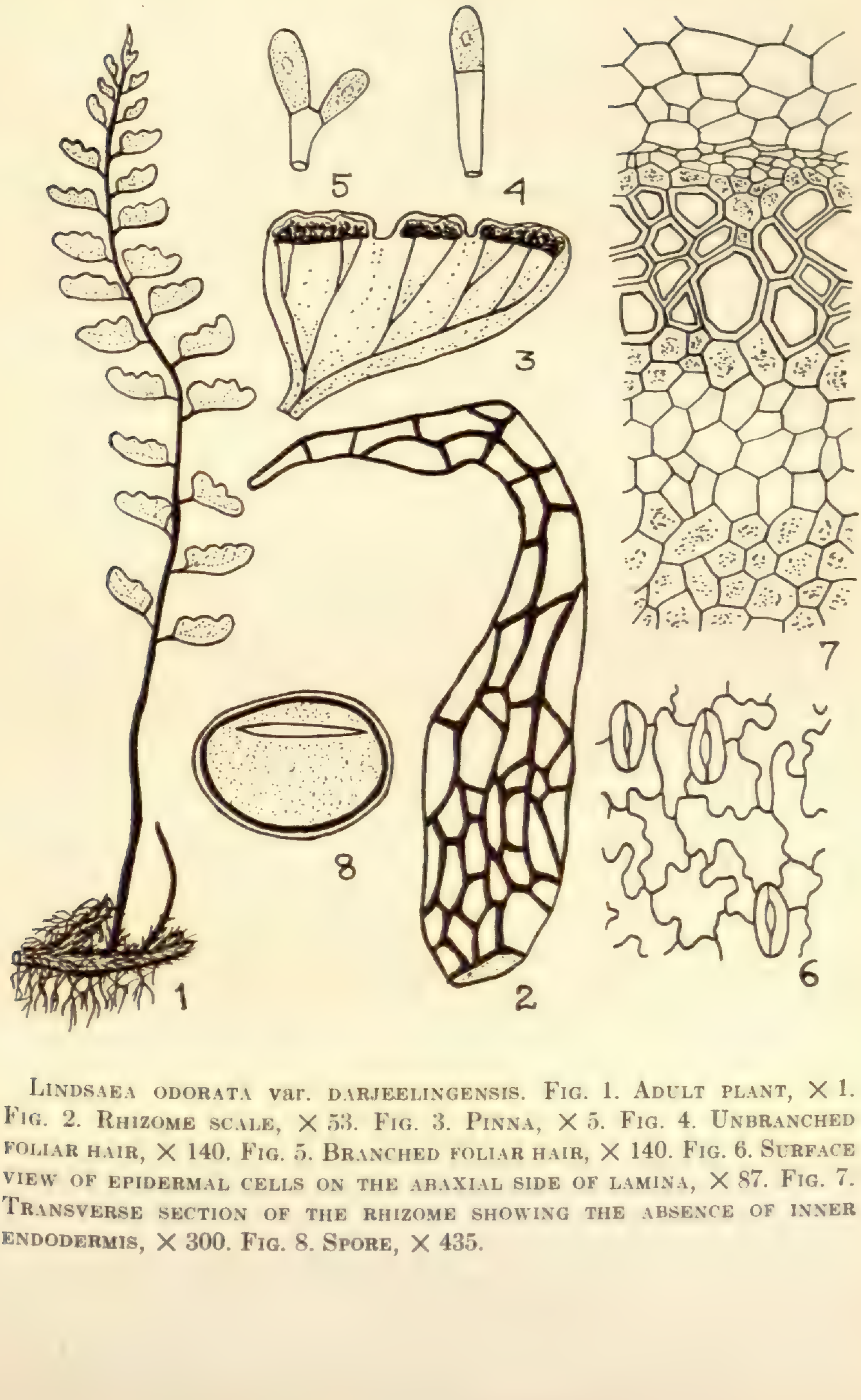
[1] We wish to thank Professor R. E. Holttum for the Latin diagnosis, and Professor S. P. Sen for his encouragement.

[2] Kramer (Blumea 15: 567, 1967) has shown this to be the correct name for what has always, but incorrectly, been called *Lindsaea cultrata* (Willd.) Swartz.



Lindsaea odorata var. darjeelingensis. Fig. 1. Adult plant, × 1. Fig. 2. Rhizome scale, × 53. Fig. 3. Pinna, × 5. Fig. 4. Unbranched foliar hair, × 140. Fig. 5. Branched foliar hair, × 140. Fig. 6. Surface view of epidermal cells on the abaxial side of lamina, × 87. Fig. 7. Transverse section of the rhizome showing the absence of inner endodermis, × 300. Fig. 8. Spore, × 435.

OTHER SPECIMENS SEEN: Darjeeling-Sudrapong Road, *Sen & Sen 506*; Rangaroon Forest, *Sen & Sen 507*; Lebong, *Sen & Sen 508*; Darjeeling, *G. King BSI 5341, 5344* (CAL).

This new variety somewhat resembles var. *pallens* Hook. (Sp. Fil. **1:** 204. 1846) from Nepal and Sylhet in frond size, and yet differs in other characters. The features which distinguish and characterize var. *pallens* are: (i) the scales are less than 4 cells wide at the base, (ii) short branched hairs and multicellular hairs are seemingly absent even on the youngest fronds, (iii) the vascular cylinder of the rhizome has both the inner and outer endodermis, and (iv) the spores measure 61 $\mu \times 44\ \mu \times 48\ \mu$. We conclude that var. *darjeelingensis* is a very distinct local variety of this wide ranging species.

The differences among the three varieties of *Lindsaea odorata* may be summed up in the following key:

Scales 2–3 or very rarely 4 cells broad at the base; short branched hairs absent on the laminae; stele of the rhizome with both inner and outer endodermis.

Long multicellular hairs always present on young fronds; fronds ca 60 cm long and ca 35mm wide at the broadest region; laminae thick; spores 64 $\mu \times 44\ \mu \times 43\ \mu$. var. *odorata*

Long multicellular hairs never occur even on the young fronds; fronds ca 20 cm long and 24 mm wide at the broadest region; laminae thin; spores 61 $\mu \times 44\ \mu \times 48\ \mu$. var. *pallens*

Scales 4–7 cells broad at the base; short branched hairs always present on young laminae; stele of the rhizome with only the outer endodermis; long multicellular hairs never develop on the fronds; fronds ca 15 cm long and 17 mm wide at the broadest region; spores 52 $\mu \times 38\ \mu \times 33\ \mu$. var. *darjeelingensis*

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The Proper Disposition of Meniscium macrophyllum Kunze

C. V. MORTON

In our paper "The American Species of Dryopteris, Subgenus Meniscium" (Bull. Torrey Bot. Club **65:** 347–376. 1938), Dr. Maxon and I concluded that *Meniscium macrophyllum* Kunze could not properly be referred to *Dryopteris* subg. *Meniscium* because some of the sporangia are borne on the leaf surfaces between the veins, thus being "acrostichoid." Consequently, we proposed to refer the species to *Bolbitis*, where the acrostichoid condition is the rule. However, I have never been really satisfied with this disposition, because this species resembles species of the subg. *Meniscium* much more than any *Bolbitis* species in most characters.

My reexamination of the available specimens indicates that in some specimens the sporangia are borne only on the arcuate cross-veinlets and also, exceptionally in *Meniscium*, on the short, medial, outwardly excurrent veinlets also. Indeed it appears that in semifertile blades the sporangia are mostly on the excurrent veinlets (cf. *Spruce 3030*). In some specimens the sporangia do extend out also onto the leaf surfaces, which is certainly a unique character in *Meniscium* but not sufficient to necessitate the reference of this species to a different genus, especially when the character is not shown by all specimens. Therefore, I now refer *M. macrophyllum* to *Thelypteris* subg. *Meniscium*:

THELYPTERIS **macrophylla** (Kunze) Morton, comb. nov.

Meniscium macrophyllum Kunze, Flora 22(1): Beibl. 44. 1838. TYPE: Serra do Mar, Bahia, Brazil, *Martius 363* (isotypes BR, K, NY).

?*Heteroneuron meniscioides* Fée, Mém. Foug. 2: 93, *t. 55*. 1845. TYPE: Bahia, Brazil, *Blanchet* (not seen). I have seen two specimens collected by Blanchet in Bahia, numbers 2228 and 2477, both at Kew, and these are very likely authentic and parts of the type collections.

?*Poecilopteris meniscioides* (Fée) K. B. Presl, Epim. Bot. 175. 1849 [1851].

Phegopteris macrophylla (Kunze) Mett. Fil. Lechl. **2**: 24. 1859, at least as to basionym.

Nephrodium macrophyllum (Kunze) Keys. Pol. Cyath. Herb. Bung. 48. 1873.

Dryopteris macrophylla (Kunze) C. Chr. Ind. Fil. Suppl. **1:** 35. 1913.

Bolbitis macrophylla (Kunze) Maxon & Morton, Bull. Torrey Bot. Club 65: 375. 1938.

ADDITIONAL SPECIMENS EXAMINED:

BRAZIL: San Isidro, Goyaz, *Pohl* (BR). Limocero, Goyaz, *Pohl* (BR). Serra do Mar, Bahia, *Luschnath*[1] (BR). Ilheos, Bahia, *Luschnath*[1] (BR). Without locality, *Riedel* (BR, sterile).

SURINAME: Jodensavanne-Mapanne Creek, Suriname River, *Lindeman 4945* (U); *Hekking 1212* (U). Blanche Marievallen, Nickerie River, *Maas & Tawjoeran 10987* (U).

BRITISH GUIANA: *Appun 732* (K).

In our discussion of this species, Maxon and I decided that specimens with setose sporangia ought to be referred also to *B. macrophylla*, but I have now changed my mind about that also. The type of *M. macrophyllum* and other Brazilian specimens that I have recently examined (but not all of those cited in 1938 have been reexamined) have the sporangia non-setose. Those from Trinidad and Tobago and some of those from the Guianas have them conspicuously setose, and in a peculiar way. The setae, numbering from one to four, are exceedingly conspicuous and are borne on the annulus. In the other species of *Meniscium* with setose sporangia we stated that the setae are borne on the stalk of the sporangium. I am now unable to verify this in all cases. Sometimes the seta *is* on the sporangium stalk, but at other times it seems to be only from the receptacle rather than the sporangia, thus being technically a paraphysis. It may be that these setae are too easily detached and are separated from their sporangium readily in making a microscope slide. However this may be, it does seem that the character is still a usable one in separating those species with setose sporangia or paraphysate sori from those with glabrous sporangia and sori. Since I have used this character of setose sporangia as a fundamental character in this group, it is not reasonable to allow both types within *T. macrophylla*, especially since there is some geographic disjunction and some other characters of more debatable importance. It appears that in typical *T. macrophylla* the excurrent veinlet is well developed

[1] These collections may very well be isotypes, for the specimens distributed by Martius in his numbered sets were often collected by others, among them Luschnath. They are in any case topotypes and quite identical to *Martius 363*.

in the fertile pinnae, and it bears sporangia. In the plants with setose sporangia the arcuate cross veinlets are nearly straight and the excurrent veinlet is generally reduced to a mere knob hardly long enough to bear sporangia. This character ought to be checked in the field. I do not have enough good fertile material. This plant with setose sporangia may be known as:

THELYPTERIS **guyanensis** (Fée) Morton, comb. nov.

Meniscium guyanense Fée, Gen. Fil. 224. 1852. TYPE: "Habitat in sylvis paludosis, ad amnes Conana et Gabaret," French Guiana, *Leprieur* in 1835 (originally determined as *M. sorbifolium*) (P?, not seen). The description, especially the statement that the sporangia are pilose, indicates that the name refers to this species.

Acrostichum fendleri Baker, Journ. Bot. Brit. & For. 25: 100. 1887. TYPE: Trinidad, *Fendler 88* (presumably K, not seen; isotypes NY, US).

Meniscium oligophyllum Hort. ex Baker, Ann. Bot. **5**: 487. 1891. LECTOTYPE: Hort. Linden, ex Herb. Moore (K). A specimen "e caldario Linden" in Brussels is probably an isolectotype (Weatherby photograph US). A later collection, doubtless from authentic material, is cult. Jan. 7, 1871, ex Herb. R. Sims (K). Probably this name ought to be considered as invalid, since it was not definitely accepted as a valid species by the publishing author, Baker.

Leptochilus fendleri (Baker) C. Chr. Ind. Fil. 385. 1906. Based on *Acrostichum fendleri* Baker (not *Meniscium fendleri* Eaton[2]).

Dryopteris anceps Maxon, Contr. U.S. Nat. Herb. **24:** 62. 1922. Based on *Acrostichum fendleri* Baker, not *Dryopteris fendleri* (D. C. Eaton) Kuntze (1891).

I have not been able to reexamine all the specimens cited in 1938. Those from the Guianas should be rechecked, since both *T. macrophylla* and *T. guyanensis* grow there.

SPECIMENS OF T. GUYANENSIS EXAMINED:

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[2] In the "Index Filicum" the citation for this combination is given as C. Chr. Bot. Tidsskr. **26**(2): 285. 1904, but at this place it is given as merely *Leptochilus fendleri* (Eat.), with no basionym cited. There is, in fact, no Eaton name that could be a basionym. As shown in the "Index Filicum," Christensen was under the impression that the name *Meniscium fendleri* Eaton existed and that *Acrostichum fendleri* Baker was a transfer of it to *Acrostichum*, but Eaton never published such a name at the place cited by Christensen or elsewhere, as pointed out by Maxon (Contr. U.S. Nat. Herb. **24:** 62. 1922, footnote), and Baker's *A. fendleri* was a new species. However, Christensen's reference to *Acrostichum fendleri* Baker under *Leptochilus fendleri* in the "Index Filicum" serves to validate the combination, with the change of parenthetical author from Eaton to Baker.

TRINIDAD: Orange Road, *Hombersley 226* (US). Brazil, *Britton, Britton & Freeman 2121* (US); Without locality, *Fendler 88* (NY, US); Bot. Gard. Herb. *1584* (US).

TOBAGO: Between Roxborough and Parlatuvier, *Broadway 4904* (US)

SURINAM: Julianatop, Wilhelmina Mountains, 500 m., *Schulz 10451* (U). Maratakka-Saparra, *Gonggrijp & Stahel 971* (U, US). Bakhuis Mountains, between Kabalebo River and Left Coppename River, *Florschutz & Maas 3054* (U).

BRITISH GUIANA: Barina River, *Jenman* (NY, 8 sheets). Demerara River, *Jenman* (NY).

These two species, *T. macrophylla* and *T. guyanensis*, are most likely to be confused with *T. chrysodioides* (Fée) Morton and its variety *goyazensis*, which also have the fertile leaves smaller than the sterile, the blades being therefore subdimorphic. The other large species that might be confused are included in the following key:

Sporangia non-setose.

Sporangia confined to the arcuate cross-veinlets; bases of pinnae broad, not cuneate.

Pinnae broadest at base (Florida, West Indies, Margarita Island [Venezuela]).....*T. reticulata* (L.) Proctor

Pinnae broadest above base (Costa Rica).

T. turrialbae (Rosenst.) Morton

Sporangia on the arcuate veinlets, the excurrent veinlets, and sometimes also on leaf tissue; pinnae cuneate at base (Brazil, Peru, Guianas, Amazonlan Venezuela).

T. macrophylla (Kunze) Morton

Sporangia setose on the stalk or annulus.

Sporangia setose on the annulus;[3] arcuate veinlets nearly straight, the excurrent veinlet often reduced to a mere knob (Trinidad, Tobago, Guianas).....*T. guyanensis* (Fée) Morton

Sporangia setose only on the sporangium stalk;[3] excurrent veinlet well developed, not bearing sporangia (Guianas, Brazil).

T. chrysodioides (Fée) Morton var. *chrysodioides*[4]

T. c. var. *goyazensis* (Maxon & Morton) Morton

NATIONAL MUSEUM OF NATURAL HISTORY, WASHINGTON, D. C. 20560.

[3] This character is sometimes not easily determinable. It is likely that the setae are early deciduous and sometimes not present on mature material.

[4] The species *T. chrysodioides* is accepted here as construed in our 1938 paper, but whether correctly or not is not really determinable until Fée's type is located.

The Thelypteris normalis Complex in the Southeastern United States[1]

A. REID SMITH

The species of the *Thelypteris normalis* complex in the southeastern United States and the West Indies have long been acknowledged as taxonomically troublesome. The first person to monograph the group was Christensen (1913), who treated it under *Dryopteris*, subg. *Cyclosorus*. More recent workers have also recognized the integrity of the group, but generally have treated it as a subgroup of *Thelypteris* (Small, 1938; Wherry, 1943, 1964).

The chief problems encountered by Christensen and others have been the extreme variability in the species and the large number of "forms" which are seemingly intermediate between species. Robert and Edward St. John, avid collectors of Florida ferns in the 1930's, added to the proliferation of names when they described numerous Florida "endemics." The assiduousness of previous workers, however, has laid the groundwork for more detailed studies utilizing cytology and field-to-greenhouse transplants, an approach which I believe has clarified the systematics of the group.

A revision of *Thelypteris* sect. *Cyclosorus* in the New World is currently being prepared for future publication. However, in order that the important conclusions of this study might be more immediately available to those with an interest in ferns of the southeastern United States and to those involved in the preparation of floras, it seems appropriate to publish a portion of the study dealing with the species of this area. Following a key to the species and varieties is a synopsis of the southeastern United States taxa, excluding *T. totta* (= *T. gongylodes*), which is only rather distantly related to species in the *T. normalis* complex. Important aspects of synonymy, habitat, distribution, and a discussion of

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[1] Much of this research was conducted under a National Defense Education Act Fellowship.

the salient differences among the taxa are given, together with a table summarizing the cytological findings of this study. Documentation of chromosome numbers will be presented elsewhere.

KEY TO THE SPECIES AND VARIETIES OF THELYPTERIS SECT. CYCLOSORUS IN THE SOUTHEASTERN UNITED STATES

1. Basal veins of adjacent segments united below the sinus with an excurrent vein leading toward the sinus; costules, veins, and often lamina above hairy.
    2. Rhizomes long-creeping, black, nearly naked; costae below with light-colored scales; lamina, veins, costules, and costae above glabrous, or sparsely pubescent with very short hairs.
        3. Lamina and veins pubescent below; indusia and costal scales hairy.....*T. totta* var. *hirsuta*
        3. Lamina and veins glabrous below; indusia and costal scales glabrous or with sparse hairs.....*T. totta* var. *totta*
    2. Rhizomes short-creeping or suberect; costae below without scales; adaxial surface of lamina glabrous or hairy; veins, costules and costae above moderately to rather densely hairy with rather long stout hairs.
        4. Costae below with predominantly short hairs uniform in length (less than 0.2 mm and usually less than 0.1 mm long); excurrent veins mostly greater than 2 mm long; stipes purplish; fronds with usually more than two pairs of greatly reduced pinnae at the base.....1. *T. dentata*
        4. Costae below with most hairs greater than 0.3 mm long (some exceeding 0.5 mm), not uniform; excurrent veins less than 2 mm long; stipes stramineous; fronds with 0–2 pair(s) of slightly reduced pinnae at the base.
        2. *T. quadrangularis* var. *versicolor*
1. Basal veins of adjacent segments free below, or connivent at the sinus; costules, veins, and lamina above with or without hairs.
    5. Rhizomes suberect to erect, massive; basal segments of the lower and medial pinnae usually narrowly elongate parallel to the rachis; auricles (enlarged basal acroscopic pinna segments) often present at the base of the lower pinnae; costae below without scales.....3. *T. patens* var. *patens*
    5. Rhizomes long-creeping to short-creeping, the stipes arcuate at the base; basal segments of the lower and medial pinnae either reduced, the same size as, or slightly longer than more distal pinnules; auricles small or absent; costae below with or without small scales.

6. Costae, costules, and veins above with at least a few rather stout hairs mostly greater than 0.3 mm long; lamina above often rather glandular; scales absent on mature fronds on rachis and costae below.
   7. One or two pairs of basal pinnae somewhat reduced; rhizomes short-creeping, sometimes appearing suberect; venation variable, even on the same frond, from anastomosing with a short excurrent vein to connivent at the sinus; lamina above often somewhat hairy; veins above always with stout hairs, many greater than 0.4 mm long.....2. *T. quadrangularis* var. *versicolor*
   7. Lowermost pinnae usually not reduced; rhizomes short-creeping to long-creeping; veins connivent at the sinus or the distal one of each pair meeting the margin slightly above the sinus; lamina above glabrous or sparsely hairy; veins above with or without long stout hairs.....4. *T. normalis*
6. Costae, costules, and veins above glabrous or with very thin short hairs mostly less than 0.2 mm long; lamina above eglandular; a few scales persistent on rachis and sometimes costae below (absent in *T. ovata* var. *ovata*).
   8. Terminal "pinna" usually at least 5 times as long as wide; scales on costae below often numerous; lamina coriaceous; lower pinnae (at their widest point) often less than 1.2 cm wide, incised 0.5–0.7 of their width. 5. *T. augescens*
   8. Terminal "pinna" less than 5 times as long as wide; scales on costae below absent or relatively sparse; lamina chartaceous to subcoriaceous; lower pinnae (at their widest point) usually greater than 1.2 cm wide, incised 0.6 to often more than 0.8 of their width.
      9. Scales usually absent on the costae below; lamina above glabrous.....6. *T. ovata* var. *ovata*
      9. A few very narrow scales usually present on the costae below; lamina above minutely pubescent or glabrous.....6a. *T. ovata* var. *lindheimeri*

1. THELYPTERIS DENTATA (Forssk.) E. St. John, Amer. Fern J. 26: 44. 1936.

Polypodium dentatum Forssk. Flora Aegypt.-arab. 185. 1775. HOLOTYPE: mountains of southwestern Arabia, Yemen, *Forsskål s.n.* (C-Herb. Forsskålei 809! photographs K, UC!)

Polypodium molle Jacq. Coll. **3**: 188. 1789, *non* Schreb. 1771; *nec* All., 1785. HOLOTYPE: cultivated in the Botanical Garden, Schoenbrunn, and said (probably incorrectly) to originate from Caracas, Venezuela (W! photograph UC!).

Aspidium molle Swartz, J. Bot. Schrad. **1800**(2): 34. 1802. To be considered a new name under Art. 72 (Note) for *Polypodium molle* Jacq., 1789.

Aspidium violascens Link, Hort. Berol. **2**: 115. 1833. HOLOTYPE: cultivated in the Botanical Garden, Berlin, from plants said (probably incorrectly) to originate from Brazil (B, not seen; isotypes HBG! photographs UC! US!; L! photograph UC! US!).

Dryopteris mollis (Swartz) Hieron, Hedwigia **46**: 348. 1907.

Dryopteris dentata (Forssk.) C. Chr., Dansk. Vid. Selsk. Skr. VIII, **6**: 24. 1920.

Thelypteris reducta Small, Ferns Southeastern States. 254. 1938. LECTOTYPE (chosen herein): "Inter Bowling Green et Fort Green [Hardee Co.], Florida", 7–11 Dec. 1934, *E. St. John, R. St. John, W. A. Knight,* and *J. K. Small, s.n.* (NY!).

HABITAT AND DISTRIBUTION: Roadsides, pastures, edges of woods, and other disturbed habitats; also limestone sinks. Tropical and subtropical North and South America, with the possible exception of the Andean countries. This species is a common "weed" of waste areas in tropical Africa, Asia, and the Pacific Islands. In Florida, *T. dentata* is probably confined to hammocks, especially those of a limestone nature.

There is the strong indication that this species is not native to the New World but has been introduced rather recently (Smith *in* Strother and Smith, 1971). The earliest United States collection I have seen is from near Mobile, Alabama, in 1904. It was probably not collected in Florida until 1930, when it was found in Hernando County. Subsequently, it has been found in at least ten Florida counties and appears to be increasing its range, both in Florida and throughout the New World. Single collections I have seen from Georgia, Kentucky, and Louisiana are probably all escapes from cultivation. That *T. dentata* has escaped from cultivation is not surprising, since it is a very common fern in greenhouses in the United States. Its native relative, *T. quadrangularis,* is rarely cultivated.

From *T. quadrangularis*, *T. dentata* differs in the longer excurrent vein, the uniformly short pubescence below (long or long and short hairs mixed in *T. quadrangularis*), and the purplish color of the stipe and rachis (stramineous in *T. quadrangularis*). *Thelypteris dentata* has been counted many times as tetraploid ($n = 72$) from both Old and New World collections, while *T. quadrangularis* is diploid.

2. THELYPTERIS QUADRANGULARIS (Fée) Schelpe var. **versicolor** (R. St. John) A. Reid Smith, comb. nov.

Thelypteris macilenta E. St. John, Amer. Fern J. 26: 50, 52, *pl.* 5. 1936. HOLOTYPE: 7 mi NW of Brooksville, Annuttalagga Hammock, Florida, *E. St. John 204* (NY! photograph UC!; isotypes MO!, 2-NY!, US!).

Thelypteris versicolor R. St. John in Small, Ferns Southeastern States. 250, *cum tab.* 1938. HOLOTYPE: Brooksville, Hernando Co., Florida, *R. St. John 109* (NY! photograph UC!).

Thelypteris × *versicolor* R. St. John (*pro* sp.). *Stat. emend. in* Wherry, Southern Fern Guide 120. 1964.

HABITAT AND DISTRIBUTION: Woods and limestone sinks along the southeastern coastal plain from South Carolina to eastern Texas; also known from Cuba. Other varieties of *T. quadrangularis* are found in Mexico, Central and South America, Africa, and probably Malesia (Holttum, pers. comm.).

Although previously considered either a species or a hybrid between *T. dentata* and *T. normalis*, *T. versicolor* is best treated as a variety of the widespread *T. quadrangularis*, differing from the type of *T. quadrangularis* (from French Guiana) by its connivent or weakly united veins, short-creeping rhizome, and distribution. Typical *T. quadrangularis* from the Lesser Antilles, and Central and South America has united basal veins and an erect rhizome. In the West Indies, var. *versicolor* grades into two other varieties of *T. quadrangularis*, including the type variety, making specific recognition impossible.

Wherry (1964, p. 120) treated *T. versicolor* as a hybrid, stating that the sori tend to be "sparse and poorly developed, and [the]

spores mostly aborted. [*Thelypteris versicolor* is] Manifestly of hybrid origin between distantly related taxa," meaning *T. dentata* and *T. normalis*. I have examined spores of *versicolor* throughout its range and find that they are normal in appearance. Chromosome counts from Louisiana and Florida (*Table I*) show that var. *versicolor* is a diploid with 36 pairs of chromosomes at meiosis. This contrasts with the tetraploid condition in both *T. normalis* and *T. dentata*.

Thelypteris macilenta, known only from the type and from specimens propagated from the original clone, appears distinct but is no more than an aberrant element within var. *versicolor* The rhizome habit, small size of the fronds, reduced pinnae below, pinna shape, and stout hairs on the ultimate veins and costules both above and below all suggest this relationship.

3. THELYPTERIS PATENS (Swartz) Small, Ferns Southeastern States 243. 1938.

Polypodium patens Swartz, Prodr. 133. 1788. LECTOTYPE (chosen herein): Jamaica, *Swartz s.n.* (S-PA! photograph UC!).

Aspidium stipulare Willd., Sp. Pl. ed. 4, 5: 239. 1810. HOLOTYPE: *Plumier*, Tract. Fil. *pl. 23*!

Aspidium macrourum Kaulf. Flora 6: 365. 1823. HOLOTYPE: Martinique, *Sieber 354* (not seen; isotypes L, photograph US!, M!, MO!).

Nephrodium albescens Desv. Mém. Soc. Linn., Paris 6: 258. 1827. HOLOTYPE: Jamaica, *collector unknown* (P, not seen, photograph US!).

HABITAT AND DISTRIBUTION: Common along roadsides and paths, edges of woods, and open woods in the West Indies, southern Mexico, Central America, and south to southern Brazil and Bolivia. From the United States I have seen only a single specimen: Florida, Dade Co., S of Miami, Feb.–Mar. 1905 *A. A. Eaton s.n.*, (US!).

Thelypteris patens var. *patens* can be distinguished from most New World taxa in *Cyclosorus* by its erect rhizome and by the stipe base scales, which are ovate-lanceolate, light brown, and glabrous. The basal pinna segments in var. *patens* are either elongate and acuminate, or the acroscopic segment is expanded

into a deeply pinnatifid auricle up to 5 cm long. Without the rhizome, a specimen of *T. patens* is sometimes difficult to distinguish from specimens of *T. normalis*. The latter species has hairs on the costules and ultimate veins above and the lamina above is frequently glandular. The blade above in *T. patens* var. *patens* is glabrous except for hairs along the costa. All specimens of *T. patens* thus far counted have been tetraploid ($n = 72$).

4. THELYPTERIS NORMALIS (C. Chr.) Moxley, Bull. So. Calif. Acad. **19:** 57. 1920.

Dryopteris patens var. *glandulosa* A. A. Eaton, Bull. Torr. Club **33:** 477. 1906. HOLOTYPE: Colwell's Hammock, Dade Co., Florida, *A. A. Eaton 185* (GH! photographs MO!, UC!).

Dryopteris normalis C. Chr. Ark. för Bot. 9(11): 31. 1910. SYNTYPES: Jamaica, *Jenman Herb. s.n.* (NY!).

Thelypteris saxatilis R. St. John *in* Small, Ferns Southeastern States 236. 1938. HOLOTYPE: Ellaville, along the Suwanee River, [Madison Co.], Florida, *R. St. John 86* (NY!).

Thelypteris unca R. St. John *in* Small, Ferns Southeastern States. 246. 1938. HOLOTYPE: Costello Hammock, Dade Co., Florida, *R. St. John 172*, 2 sheets (NY! photograph UC!).

Thelypteris macrorhizoma E. St. John, Amer. Fern J. **32:** 146. 1943. HOLOTYPE: Sheep Island, The Cove, 6 mi from Floral City, Citrus Co., Florida, *E. St. John 1273* (FLAS! photograph UC!; isotypes GH?, US! photograph UC!).

HABITAT AND DISTRIBUTION: Common in woodlands, limestone sinks, gullies, and wet roadsides in open or partially shaded situations. United States: coastal plain from South Carolina to eastern Texas. Bermuda, Bahama Islands, Greater Antilles. Tortola, and from Costa Rica north through the Yucatan peninsula to southern Tamaulipas, Mexico. Rare in the Lesser Antilles, northern Venezuela, and northeastern Brazil. Reports by Morton (1967) that it occurs south to Bolivia are dubious.

Thelypteris normalis is a well-characterized species but it has been either too broadly or too narrowly construed by most taxonomists. It can best be distinguished from *T. ovata* by the usually hairy costules and veins above, and by the stipitate glands

on the adaxial surface of the lamina. In general, the pinnae of *T. normalis* are not so deeply incised as those of *T. ovata* and the segments are less oblique. Sori in *T. normalis* are medial to supramedial, whereas in *T. ovata* they are supramedial to submarginal. The presence of single-celled glands on the sporangial stalks and the absence or paucity of glands on the indusial margin are excellent characters for distinguishing *T. normalis* from *T. ovata*, where the situation is reversed (glands always absent on sporangial stalks but present and often abundant on the indusial margin). Throughout most of its range, *T. normalis* is easily distinguished from *T. quadrangularis* by venation, but in the southeastern United States, *T. quadrangularis* var. *versicolor* often has the basal pair of veins only weakly united or merely connivent at the sinus. *Thelypteris normalis* can then best be identified by the lowermost pinnae being usually not reduced (the lamina deltoid rather than ovate-lanceolate in outline), by the lack of hairs on the leaf tissue between the veins above, by its generally longer creeping rhizome, and by the slightly thicker blade texture.

Thelypteris normalis hybridizes with *T. augescens*, *T. ovata* var. *ovata*, and probably *T. quadrangularis*, although hybridization with the last-named taxon has not yet been cytologically verified. In all cases examined the resulting hybrids are sterile.

Morton (1967) attempted to show that there are at least two names with priority over *Dryopteris normalis* C. Chr. One of these, *Aspidium germanii* Fée, I have placed in synonymy under *Thelypteris quadrangularis*. Unfortunately, the type of the second, *Nephrodium kunthii* Desv., has not been available for study, but I believe that it very likely is not *T. normalis*, but rather a variety of *T. patens*.

Thelypteris saxatilis and *T. unca* are both easily included within the latitude of variation of *T. normalis*. *Thelypteris saxatilis* is a somewhat smaller form than is usual for the species; some of the specimens so labeled by St. John are referable instead to *T. ovata* rather than *T. normalis*. *Thelypteris unca* differs from most specimens of *T. normalis* mainly in its slightly more falcate pinnules. *Thelypteris macrorhizoma* is less pubescent than "typical" *normalis*,

but differs in no other significant way.

5. THELYPTERIS AUGESCENS (Link) Munz & Johnston, Amer. Fern J. **12**: 75. 1922.

Aspidium augescens Link, Fil. Sp. 103. 1841. TYPE. Cuba, *Otto 89*, right hand plant (B! photograph UC!; additional authentic material is at BR! and UC!). Cultivated in the Botanical Garden, Berlin, from plants said to be from Caracas. Christensen (1913) discussed the origin of the type material and concluded, no doubt correctly, that the type locality must have been Cuba.

HABITAT AND DISTRIBUTION: Dade Co., Florida, Cuba, and on the islands of Andros and New Providence in the Bahamas. Generally on exposed limestone outcrops in moist to moderately dry open sites.

Thelypteris augescens can be distinguished readily from its close relative *T. ovata* by the more numerous paleae on the costae below, by the more coriaceous blade, by the greater pinna length/width ratio, by the less deeply incised pinnae, and by the usually distinct terminal "pinna." Glands are absent on the sporangial stalks, but usually present on the indusial margin, as in *T. ovata*. The West Indian *T. serra* greatly resembles *T. augescens* but can be distinguished by its even more abundant costal scales and more distinct terminal "pinna." Additionally, the basal segments of the lower pinnae in *T. augescens* are never reduced as is usually the case in *T. serra*, but are as long as or slightly longer than the more distal pinnules. Reports of *T. serra* in Florida (Small, 1938) are the result of confusion with *T. augescens*. From the Mexican and Central American *T. puberula*, *T. augescens* differs in its more coriaceous texture, the longer and narrower lateral pinnae, and the usually distinct terminal "pinna." The costal scales of *T. augescens* are longer, more numerous, and of lighter color than those of *T. puberula*. The geographic ranges of *T. augescens* and *T. puberula* do not overlap.

Thelypteris augescens hybridizes with *T. normalis* in Cuba and Dade Co., Florida. Hybrids also occur with *T. ovata* var. *ovata* in

southern Florida and the Bahamas. In both cases the hybrids are sterile and the spores abortive.

6. THELYPTERIS OVATA R. St. John *in* Small, Ferns Southeastern States 239, *cum tab.* 1938.

Dryopteris normalis var. *harperi* C. Chr. Dansk. Vid. Selsk. Skr. VII. 10: 182. 1913. HOLOTYPE: Hawkinsville, Pulaski Co., Georgia, *R. M. Harper 1382* (US! photograph UC!; isotypes MO! NY! photograph UC!).

HOLOTYPE: Lecanto, Citrus Co., Florida, *R. St. John 394* (NY!).

HABITAT AND DISTRIBUTION. Hammocks and limestone sinks along the southeastern coastal plain from S. Carolina to Alabama Andros and New Providence in the Bahamas.

6a THELYPTERIS OVATA VAR. **lindheimeri** (C. Chr.) A. Reid Smith, **comb. nov.**

Dryopteris normalis var. *Lindheimer* C. Chr. Dansk. Vid. Selsk. Skr. VII, 10: 182. 1913. HOLOTYPE: Texas, *F. Lindheimer 742* (B! photograph UC!; isotypes MO! UC! US! photograph UC!).

Thelypteris × *lindheimeri* (C. Chr.) Wherry, Southern Fern Guide 346. 1964.

HABITAT AND DISTRIBUTION: Riverbanks and moist canyons from central Texas south to northern Veracruz and Puebla; apparently most common in Texas and the states of Nuevo Leon, Tamaulipas, and San Luis Potosí in Mexico.

The characters which best distinguish *T. ovata* from its closest relatives, namely *T. normalis* and *T. augescens*, have already been discussed.

Two forms of *T. ovata* var. *ovata* occur in southern Florida which are rather different from each other, and at the same time are unlike specimens from central and northern Florida. One of these is found chiefly in the Everglades and is characterized by fronds frequently greater than one meter long and pinnae 18–25 cm long. The second form occurs in lime sinks and along roadsides and river banks. Its fronds are seldom greater than 0.5 m long and its

pinnae are much shorter, often less than 10 cm long. These two forms are alike in nearly all other characters. When grown under uniform greenhouse conditions, these forms show much less pronounced size differences and there is little doubt that they belong to the same species.

The presence of linear scales (mostly 0.5–1.0 mm long) on the costae below is the best character for distinguishing var. *lindheimeri* from the type variety. In addition, the blade is usually less broadly deltoid than in var. *ovata*. There are often minute hairs about 0.1 mm long on the lamina above in var. *lindheimeri*; these are absent in var. *ovata*. The two varieties are allopatric.

TABLE I. SUMMARY OF CHROMOSOME NUMBERS IN SPECIES AND HYBRIDS OF THELYPTERIS SECT. CYCLOSORUS FROM THE SOUTHEASTERN UNITED STATES AND NEIGHBORING REGIONS.[1]

Taxon	*Chromosomes at meiosis*	*No. populations sampled*[1]
T. augescens	72 II	2
T. dentata	72 II	3
T. normalis	72 II	28
T. ovata var. ovata	36 II	13
T. patens	72 II	1
T. quadrangularis var. versicolor	36 II	9
T. augescens × normalis	ca. 36 II + 72 I	2
T. augescens × ovata	ca. 36 II + 36 I	2
T. normalis × ovata	ca. 36 II + 36 I	4

[1] For most populations, several plants were counted.

LITERATURE CITED

CHRISTENSEN, C. 1913. A monograph of the genus Dryopteris. Part I. The tropical American pinnatifid-bipinnatifid species. Dansk. Vid. Selsk. Skr., Ser. VII. Nat. og Math. Afd. **10**: 55–282.

MORTON, C. V. 1967. Studies of fern types. I. Contr. U. S. Nat. Herb. **38**: 29–83.

SMALL, J. K. 1938. Ferns of the Southeastern States. Science Press, Lancaster, Pa.

STROTHER, J. L., and A. R. SMITH. 1970. Chorology, collection dates, and taxonomic responsibility. Taxon 19: 871–874.
WHERRY, E. T. 1943. Observations on Florida ferns. Amer. Fern J. 32: 139–145.
————. 1964. The Southern Fern Guide. Southeastern and South-Midland United States. Doubleday, Garden City, New York.

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Asplenium pinnatifidum × trichomanes—A New Record for Indiana

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One of the most interesting aspects of the 1970 foray of the American Fern Society was the discovery of a new record for the state of Indiana, the rare hybrid *Asplenium pinnatifidum* × *trichomanes*. The population dynamics demonstrated by Wagner (1954) in the Appalachian Spleenworts are again illustrated by this natural hybrid, which was previously known only as a single plant from southern Illinois (Wagner & Wagner, 1969). The specimen here reported was discovered by the author—and nearly simultaneously by Rolla M. Tryon—in a pocket on a south-facing sandstone cliff at McBride's Bluff along the east fork of White River in Martin county, Indiana, about six miles north of Shoals on August 22, 1970. Rolla Tryon and the author had been attracted to this particular portion of the area's extensive sandstone cliffs by Amy and James Mason and Lynda Cole, other foray members, who were investigating a peculiar variant of *Woodsia obtusa* on an adjacent east-facing spur of the outcrop.

Like the specimen reported by Wagner and Wagner, the present hybrid is morphologically intermediate between the parental species. The pinnae are quite like those of *A. trichomanes* (*Plate 6*), but express the influence of the *A. pinnatifidum* genome in being more broadly attached to the rachis. The influence of *A. pinnatifidum* is also evidenced by the long-tapering lobed apex of several of the hybrid's leaves. The petiole and proximal part of

Asplenium specimens from sandstone cliffs at McBride's Bluff near Shoals, Indiana. Fig. 1. Representative leaf of A. pinnatifidum Nutt. Fig. 2. Representative leaf of A. trichomanes L. Fig. 3. A. pinnatifidum × trichomanes.

the rachis is brown (with brown streaks often extending to the second to fourth pair of pinnae) and half-terete to adaxially channeled as in *A. trichomanes*, whereas distal to that the rachis is green and adaxially more flattened as in *A. pinnatifidum*. The minute, clathrate, trichomoid scales on the petiole and rachis of the hybrid are similar to those in *A. pinnatifidum*, whereas these are absent in *A. trichomanes*. With few exceptions, the sporangia of the hybrid are clearly abortive. Occasional sporangia in several sori are rather normally developed, but even these evidently bear aborted spores whose number is uncertain but appears to be considerably fewer than the 64 of the parental species. This may indicate the incipient development of a sporogenetic system coordinate with apogamous reproduction.

Because fixatives were unavailable in the field and the specimen did not appear fresh enough for cultivation upon arrival at Indiana University, the hybrid was not investigated cytologically. Nor have the populations of *A. trichomanes* at McBride's Bluff been examined to determine which of the ploidal levels known for this species may be represented. The leaves of the present specimen are morphologically quite similar to those figured by Wagner and Wagner in which the parental *A. trichomanes* population was diploid. Thus it is not morphologically apparent that *A. trichomanes* of higher ploidy than diploid has been involved in the parentage of this hybrid.

Voucher material of this specimen, *Gastony 949*, has been deposited in the Indiana University Herbarium at Bloomington (IND) and at the Gray Herbarium (GH).

LITERATURE CITED

WAGNER, W. H. JR. 1954. Reticulate evolution in the Appalachian Aspleniums. Evolution **8**: 103–118.

WAGNER, W. H. JR. and F. S. WAGNER. 1969. A new natural hybrid in the Appalachian Asplenium complex and its taxonomic significance. Brittonia **21**: 178–186.

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A Dwarf Ostrich Fern

H. Lou Gibson

In mid-summer 1956, I found a small, isolated, patch of ferns of a species that I did not recognize. The ferns were growing in a strip of moist, alluvial woods along the bank of the Moose River in the Adirondacks, near McKeever, Herkimer County, New York. They appeared similar to typical *Matteuccia struthiopteris* var. *pensylvanica* (*Fig. 1*), but had slightly more rounded and much shorter fronds (*Fig. 2*). They did not appear to be reproducing by offsets from their rhizomes, nor do I recall seeing any fertile fronds. The patch was separated by about 50 feet from Ostrich Ferns growing along the river bank. The land there was about one foot higher and somewhat drier than in the rather mucky flat where the small Ostrich Ferns grew.

I brought a few plants back to my wildflower garden. They persisted successfully and did not change in character with respect to size, offsetting, or fertility. In 1967 one plant did produce a stunted and twisted "fertile" frond about one inch long, tight to the crown. But no prothallia could be grown from it.

In 1964 I studied stem sections in an attempt to identify the species. The vascular strands of the dwarf Ostrich Ferns seemed identical to those of the regular ones.

In order to exclude the possibility that soil conditions in my garden maintained an environmental dwarfing, I did a few experiments. Small plants were paired as to size with young offsets from large Ostrich Ferns. Three pairs were planted in various parts of the garden. In each case the regular ferns grew to a large size, while the small ones remained unchanged now for several years. Professor Wagner, who has examined the specimens, is of the opinion that the dwarf condition is genetically fixed. The dwarf plants grew equally well in wet and drier areas of the garden, whereas the normal plants attained greater heights in a wet section than in a dry one.

In 1965 I returned to the natural site to study the original

Matteuccia struthiopteris fronds. Fig. 1. Normal frond 60 inches long. Fig. 2. Dwarf frond 15 inches long.

patch. Trees had been cleared along the strip for road building, causing a denser undergrowth. A washed-out dam had lowered the river by about two feet. Ostrich and Cinnamon Ferns were more profuse than formerly. The area was searched, but every likely *Matteuccia* of small stature could be traced by the long-creeping rhizomes back to a large, full-grown Ostrich Fern. A more detailed and lengthy search, perhaps with a ready means for identification, might rediscover the original dwarf population. The small ferns are probably overgrown by the normal species.

Some perusal of the literature and consultations with fern authorities have not uncovered any mention of a dwarf variety of the Ostrich Fern. Perhaps this report will prompt further discussion.

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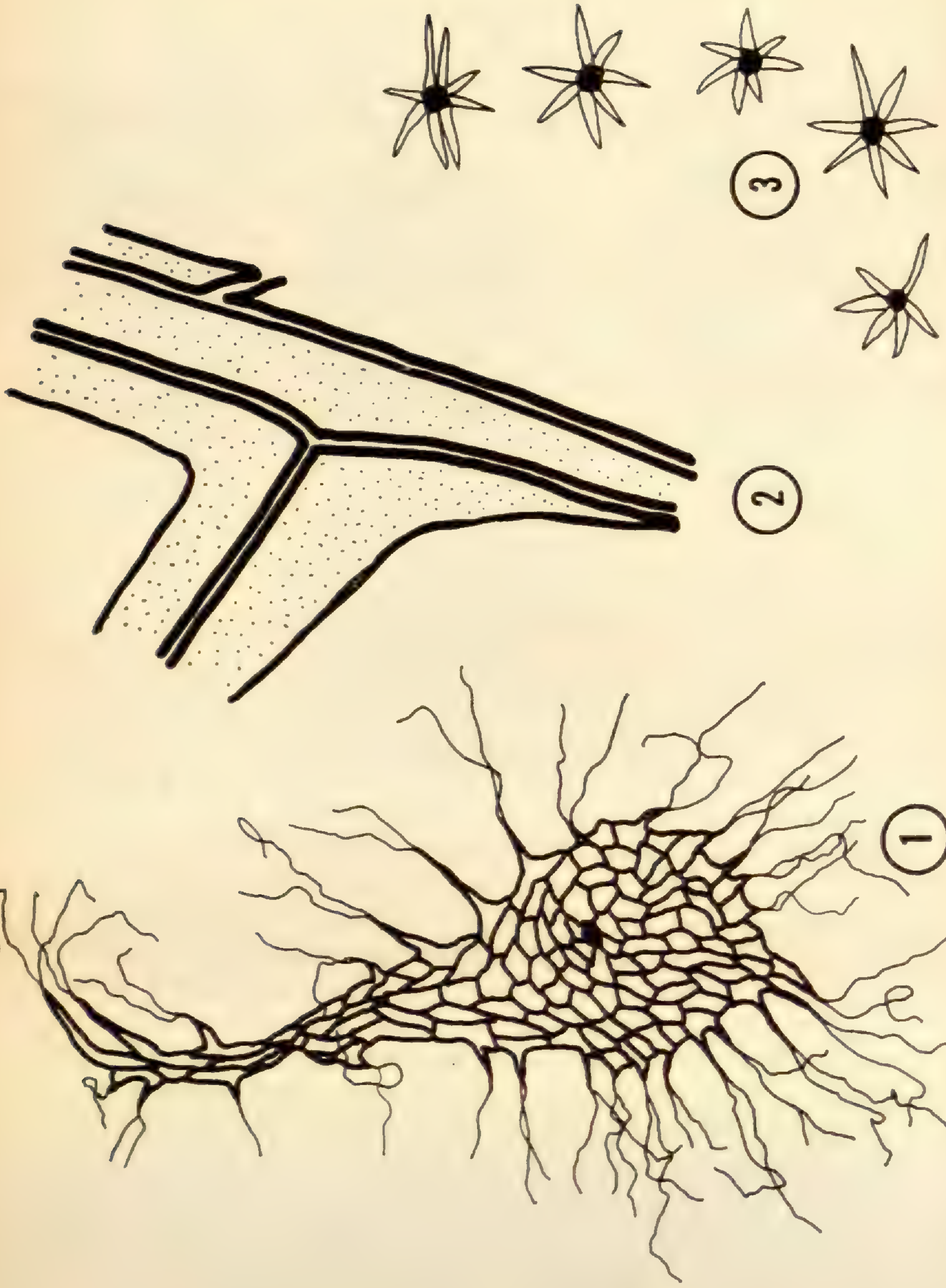
Shorter Notes

NIPHIDIUM LONGIFOLIUM, A NECESSARY NEW COMBINATION.—In Copeland's "Genera Filicum," *Niphidium*, based on *N. americanum* (Hook.) J. Smith (Hist. Fil. 99. 1875), is recognized as a distinct, monotypic genus, a native of the Andes of Ecuador. This species has been generally placed in *Cyclophorus* (now correctly *Pyrrosia*), which is a genus strictly confined to the Old World. Although *N. americanum* is somewhat like *Pyrrosia* because of its densely tomentose appearing undersurface, it is probably not closely allied. As Copeland pointed out, *Pyrrosia* has stellately branched peltate scales (*Fig. 3*) on the undersurface, whereas *Niphidium* has (under the compound microscope) beautifully clathrate scales bordered with elongate, hyaline hairs (*Fig. 1*). The hairs are usually forked at the apex and two cells wide at the base (*Fig. 2*); each cell forms one of the forks. These hairs are so numerous and dense as to make the lower surface appear densely tomentose. But the frond scales of *Niphidium* are not truly peltate and stellate, and so a resemblance to *Pyrrosia* is strictly superficial. In its *Anaxetum*-like venation and its large, round sori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uniseriate between the prominent lateral veins *Niphidium* is like *Pessopteris*, and may be related to that, which is however essentially scaleless on the lower surface.

In calling this plant *Niphidium americanum* (Hook.) J. Smith, Copeland overlooked an earlier specific name that is available. In his paper on Cavanilles' fern types, Christensen indicated that *Polypodium longifolium* Cav., from the type specimen, is identical with *N. americanum*. Therefore, the following new combination is necessary:

NIPHIDIUM **longifolium** (Cav.) Morton & Lellinger, comb. nov.

Polypodium longifolium Cav. Descr. 245. 1802. TYPE: Pelileo, near Mount Tunguragua, Ecuador, *Née* (MA, seen by Christensen).

Polypodium americanum Hook. Sp. Fil. 5: 54. 1864. SYNTYPES: Cuenca, Ecuador, *Jameson*, and Baños, Ecuador, *Spruce 5248* (both presumably K).

Niphodolus americanus (Hook.) Diels in Engl. & Prantl, Nat. Pflanzenfam. 1(4): 325. 1899.

Cyclophorus americanus (Hook.) C. Chr. Ind Fil. 198. 1905.

Cyclophorus longifolius (Cav.) C. Chr. Dansk Bot. Ark. 9(3): 11. 1937.

It should be pointed out that under *Pyrrosia* the epithet *longifolia* is not available because of the quite different Old World species *P. longifolia* (Burm. f.) Morton (J. Washington Acad. Sci. 36: 168. 1946).—C. V. MORTON AND DAVID B. LELLINGER, *National Museum of Natural History, Washington, D. C. 20560.*

BULBOUS ADDER'S-TONGUE COMMON IN LOUISIANA.—Bulbous Adder's-tongue is a very small, easily overlooked fern. I first saw it in March, 1970, accidently while looking for *Oenothera spachiana* seedlings for my wildflower garden. Most manuals consider this fern to be rare or at least uncommon. Brown and Correll (Fern and Fern Allies of Louisiana, 1942) listed it from four southeast parishes (East Feliciana, East Baton Rouge, Livingston, and Orleans), one southwest parish (Jefferson Davis) and two northeast parishes (Richland and Caldwell). They noted that it was common

FIG. 1. SCALE FROM THE ABAXIAL SURFACE OF NIPHIDIUM LONGIFOLIUM, × 24 (GILER 59). FIG. 2. SAME, DETAIL OF BASE OF DOUBLE-CELLED HAIR, × 576. FIG. 3. SCALES FROM THE ABAXIAL SURFACE OF PYRROSIA ACROSTICHOIDES, × 50 (HOLTTUM 18054).

only on the Copenhagen Prairie of Caldwell Parish. The University of Southwestern Louisiana has specimens from Bienville, Winn, Caldwell, and Rapides Parishes. Louisiana Technological University has a specimen from Union Parish. The small number of specimens and the information on the labels indicate that most collectors consider this fern to be rare.

From mid-March to mid-May, 1970, I made field trips looking specifically for *Ophioglossum crotalophoroides*. I have collected the fern in the following twenty-six parishes: Allen, Beauregard, Bienville, Bossier, Caddo, Caldwell, Catahoula, Claiborne, DeSoto, Evangeline, Franklin, Grant, Jackson, LaSalle, Lincoln, Morehouse, Natchitoches, Ouachita, Red River, Richland, Sabine, Union, Vernon, Webster, West Carroll, and Winn. Other parishes could have been added had I not been restricted in my collecting by a full teaching load. The specimens referred to above raise the number of parishes where this fern is known to grow to thirty-two.

Ophioglossum crotalophoroides is apparently absent from four parishes I checked: East Carroll, Madison, Tensas, and Concordia. They lie along the Mississippi River, and I could not find any sandy soil in them. No plants were found on the clay soils characteristic of these parishes. All collections were from sandy soils of cemetaries, pastures, road banks, power lines, pipe lines, etc. Typically these sites are mowed during the summer. In such habitats the plants of Bulbous Adder's-tongue are extremely numerous. Some cemetaries I visited contained thousands of these plants. I think there are almost as many (or as many) *Ophioglossum crotalophoroides* plants in Louisiana as there are of such common ferns as Christmas Fern and Bracken; it simply has been overlooked by collectors. One possible explanation of this is that during late March, when *O. crotalophoroides* is at its peak, there are no common showy associates—except possibly the tiny bluets, *Houstonia pusilla*, *H. minima*, and *H. pygmaea*). At this time few botanists bother to collect in such "unfruitful" territory. Also, one can walk over those ferns ten times and fail to see them. But this small fern can be seen with any degree of regularity only from the prone position. I suggest that collectors look specifically in the

proper habitats for this fern and that they get down to ground level where the plants are. *Ophioglossum crotalophoroides* is much more common than previously supposed.—DR. R. DALE THOMAS, *Department of Biology, Northeast Louisiana University, Monroe, La. 71201.*

Recent Fern Literature

FLORE DE LA NOUVELLE-CALÉDONIE ET DÉPENDANCES, NO. 3, PTÉRIDOPHYTES, by G. Brownlie. Published by Muséum National d'Histoire Naturelle, 16 rue Buffon, Paris V, France, pp. 1–307. *t. I–XXXIX*. 1969.—This beautifully prepared book is the first fern flora of any of the South Sea Islands for many years. Many of the ferns of New Caledonia are endemic, and extremely interesting because of their variability, in which they are comparable to the ferns of Hawaii.

Brownlie's treatment has full keys, descriptions, and citation of synonyms, misapplied names, and specimens. The work owes much to Madame Tardieu-Blot, who translated the descriptions into French and who had the excellent drawings prepared in Paris. In fact, the whole style and format is exactly like one of Madame Tardieu's own books on the fern floras of Gabon and Cameroun; however, Madame Tardieu disclaims any responsibility for the taxonomic treatment or other details. The comments that I give below are on minor matters. They do not detract from the value of this excellent book, which should be in the hands of all fern students.

Brownlie splits up the traditional family Polypodiaceae into 13 families, following Alston (cf. Taxon **5:** 23–25. 1956), who had a much better treatment in my opinion than that of Ching, Copeland, or other more recent authors. However, one runs into difficulties in trying to describe and key out these families, and Brownlie's key will not work well for some genera. Grammitidaceae has as one of the key characters that the petiole is generally articulate, but this is never true in this family. Vittariaceae is keyed as having the sori marginal or submarginal, but they are strictly dorsal in *Antrophyum*. *Acrostichum*, *Syngramma*, and

Aspleniopsis, which have the sori strictly dorsal, are keyed solely under the heading of sori marginal or submarginal. This merely points out that it is impossible to key out the families as recognized by single key characters. Probably the only way is to do as Copeland did in his "Genera Filicum," and have Aspidiaceae appear in ten different places in the key to the families, Pteridaceae in nine places, and so forth. Such keys are essentially keys to genera or groups of genera, rather than to families.

Many of the family names used are suspect or definitely incorrect. Azollaceae is, for instance, attributed to Christensen in Verdoorn (1938), but at the place cited there is no Latin diagnosis. Presl called his "Lindsaeaceae" a "Sectio," and since a section is a group below the rank of a genus, it can not be a proper category for a family name. The Code indicates that a family name must be called either a family or an "Ordo" (Art. 18, paragraph 3). Vittariaceae was called by Presl a "Tribus," and a tribe is also an inadmissible category for a family name. Psilotaceae is attributed to Payer (1850), but Payer had it in French as "Psilotées"; since botanical nomenclature must be in Latin, names published originally in French are not valid; cf. Code, 1966 edition, p. 213, where "Casuarinées" Mirbel, 1810, is rejected in favor of Casuarinaceae R. Brown, 1814.[1]

Many stated types are in reality lectotypes only (e.g. *Diplazium echinatum* C. Chr.). *Vieillard 1520* from Canala can not be the type or lectotype of *Blechnum confusum* (Fourn.) Brownlie, for it was not one of the collections cited; one of the syntypes was *Vieillard 1520* from Balade. Many Paris specimens are cited as "types," i.e. implicitly holotypes, when they are actually, as in the case of Labillardière species, really isotypes or isosyntypes. The type of *Microlepia* is said to be *M. speluncae* (L.) Moore, but this is impossible, since this was not one of the species originally included in the genus. The type of *Lastreopsis* is *Polypodium recedens* J. Smith, not *L. tenera* (R. Brown) Tindale, which may be

---

[1] This book is remarkably free of typographical errors; one noted is the citation of Athyriaceae Alston as "Taxon 5: 36. 1936"; it should be 5: 25. 1956.

a taxonomic synonym but which is based on an entirely different type specimen.

The only genus in which the treatment is unsatisfying is that of *Asplenium*, in which a number of species and varieties described from New Caledonia are placed in a table showing their possible origin as hybrids, but with absolutely no discussion of these, or any citations, descriptions, or typifications.

Some of the compound epithets are spelled without a hyphen, e.g. *Hymenophyllum le ratii* and *Adiantum capillus veneris*, but the Code requires such specific names to be hyphenated. The specimens that are referred to *Lycopodium nutans* Brack. (1854) are probably *L. proliferum* Blume (from unpublished annotations by Adelbert), and if this is correct the Blume name has priority. *Cyathea propinqua* Mett., a Fijian species of the subg. *Sphaeropteris*, is cited as a synonym of *C. vieillardii* Mett., which belongs in subg. *Cyathea*, according to Holttum's classification (Blumea **12**: 272. 1964). *Asplenium adiantoides* (L.) C. Chr. (1905) is accepted as a correct name, but it is an illegitimate later homonym of *A. adiantoides* Lam. (1786); I believe that the correct name is *A. polyodon* Forst. *Thelypteris uliginosa* (Kunze) Ching has *Cheilanthes setigera* Blume (1828) cited as a synonym; *T. uliginosa* is a different species fron the Javan *T. setigera;* the correct name under *Thelypteris* is *T. torresiana* (Gaud.) Alston, which has recently been called *Macrothelypteris torresiana* (Gaud.) Ching (cf. Holttum, Blumea **17**: 27. 1969). *Marattia rolandi-principis* is described as being simply pinnate, but it is sometimes bipinnate; Rosenstock distributed material as *M. rolandi-principis* var. *subbipinnata* Rosenst., an unpublished name, and the bipinnate plants were collected by Guillaumin and Baumann (no. 8663). *Nephrolepis floccigera* (Blume) Moore is cited as a synonym of *N. cordifolia*, but from the holotype (from Celebes) it is by no means that, for it has the pinnae about 12 cm long or more, not about 2 cm long as in *N. cordifolia*. *Blechnum vieillardii* var. *simplex* Fourn. is a nomen nudum at the place cited.

There are few omissions. The genus *Belvisia* [*Hymenolepis*] perhaps needs further study; only *B. mucronata* is reported.

Several collections of *Hymenolepis revoluta* var. *planiuscula* (Mett.) Hieron were cited from New Caledonia by Christensen (Dansk Bot. Ark. **6**(3): 59. 1929). *Cephalomanes australicum* v. d. Bosch was described from the Isle of Pines, which is included within this New Caledonian flora. *Pyrrosia varia* (Kaulf.) Farwell has been reported from New Caledonia but is not accounted for here. Otherwise, the only omissions noted are: *Blechnum irregulare* Carr. (New Caledonia, *MacGillivray F25*, holotype BM, Morton photograph 6685), *B. diversifolium* var. *paleaceo-setosum* Rosenst. (Fedde Repert. **8**: 75. 1910), *Lomaria attenuata* f. *monstrosa* Compton, *L. lenormandii* f. *aprica* Compton, *Asplenium adiantoides* var. *tripinnatum* Compton (= *A. robustum* Blume?), *Cyathea albifrons* var. *lata* Compton, *Hymenophyllum mnioides* f. *amplior* Compton, and *Lycopodium squarrosum* var. *pacificum* Compton.—C.V.M.

THE FERNS AND FERN ALLIES OF THE SIERRA NEVADA IN CALIFORNIA AND NEVADA, by John Thomas Howell. The Four Seasons **3**(3): 2–18. 1970.—In anticipation of his forthcoming "Flora of the Sierra Nevada," Howell has presented here a list of the ferns and fern allies with a key and an indication of the northernmost and southernmost known stations. There are altogether 62 species treated, one of which is introduced (*Cyrtomium falcatum*) and several of which are probable hybrids. "The Four Seasons" is a relatively unknown periodical issued quarterly and consists chiefly of taxonomic notes on Californian plants. It is published by the Regional Parks Botanical Garden, Berkeley, Calif. 94708; the subscription price is $6.00 per volume.—C.V.M.

American Fern Society

Report of the 1970 Fern Foray

Southern Indiana sandstone cliffs and wooded ravines, the richest sites for ferns in the state, were the focus of the Fern Foray, August 20–22, 1970. The first stop was near Taswell, in the Hoosier National Forest, an unusual deciduous forest having elements characteristic of coniferous woods, such as Hemlock, Yew, Moun-

tain Laurel, and Partridge Berry. There were abundant plants of *Asplenium platyneuron* growing in open, grassy sites leading up to the woods. *Pteridium aquilinum* var. *latiusculum*, and *Equisetum hyemale* also occurred in these open areas. One of the Gentians (*Sabatia angularis*), the False Foxglove (*Aureolaria flava*), and many composites were in good bloom. In the cool ravines were many plants of *Botrychium virginianum* and *B. dissectum* f. *obliquum*, *Adiantum pedatum*, *Diplazium pycnocarpon*, *D. acrostichoides*, *Athyrium Filix-femina* var. *asplenioides*, and *Thelypteris hexagonoptera*. Several orchids, the showy *Orchis spectabilis*, and Rattlesnake Plantain (*Goodyera repens*), as well as Bloodroot, Hepatica, Baneberry, Anemone, and Trilliums were evidence of the rich Spring flora in these woods. On the higher slopes of the ravines, among rocks fragmented from the cliffs, there were numerous plants of *Polystichum acrostichoides*, *Dryopteris marginalis*, and fewer of *D. spinulosa* var. *intermedia* and *Cystopteris fragilis*. On the spectacular, sheer cliffs, ledges were covered with *Polypodium virginianum*, and a few leaves of *P. polypodioides* were found. The pocked faces of the sandstone, especially where mosses were established, provided pockets for *Asplenium pinnatifidum* and *A. trichomanes*. One of the rare Saxifrages, *Sullivantia Sullivantii*, kept company with these Aspleniums and *Camptosorus rhizophyllus*. Some of the more energetic climbers who scaled the cliffs found, on the upper slopes, one of the uncommon ferns of Indiana, *Dennstaedtia punctilobula*.

On the afternoon trip to Pioneer Mother's Memorial Forest, near Paoli, many ferns of the ravine were seen again. This woods is one of the few remaining stands of primitive hardwoods in the state, with fine specimen trees of White Oak, Walnut, and Tulip Popular. There were several unusual orchids here—Lily Twayblade (*Liparis liliifolia*), Puttyroot (*Aplectrum hyemale*), and flowering specimens of the Nodding Pogonia (*Triphora trianthophora*).

During the evening program, at our motel, in Jasper, Rolla Tryon reviewed the recent glacial history and vegetation of the region, and discussed the species that were collected during the

Standing left to right: Neill Hall, James Montgonery, Jeanette Oliver, William and Garnet Meinders, Benton Stidd, Gregory Anderson, Donald Huttleston, John Clements, Susan and Gerald Gastony, Robert Lommasson, Mildred Faust, Rolla Tryon, James Maysilles, Mrs. R. Benedict, Victor Ries, Lawrence Dillon, W. E. and Mrs. Buker, Eva Sobol; Seated: Barbara Joe Hoshizaki, Jeanette Gross, Elinor Henry, Lynda Cole, LeRoy Henry, Alice Tryon, Amy Mason, Betty Dillon, Ralph Benedict. Photo taken by Steve Wunderle.

day. Neill Hall reported on the activities of the spore exchange and requested spores of any species, to replenish older supplies. Donald Huttleston spoke of the living fern collections at Longwood Gardens, which is actively acquiring living collections from all parts of the world. Mrs. LeRoy Henry showed her colored movies and commented on the 1967 Fern Foray, in Texas, and the 1969 International Botanical Congress, at Seattle, including some of the attractive gardens of the area. The film had many good views of Fern Society members as well as habitats in Texas and Washington.

The second day's trip was to MacBride's Bluff, another sandstone cliff area, near Shoals. *Woodsia obtusa* was abundant on the open road banks growing with the blue-flowered *Lobelia siphilitica*. Great colonies of *Polypodium polypodioides* and *Camptosorus rhizophyllus* covered boulders below the cliffs. A few plants of *Cystopteris bulbifera* were found on the cliffs and one of the uncommon ferns of Indiana, *Cheilanthes lanosa*, occurred on precarious ledges. Plants of *Asplenium pinnatifidum* and *A. trichomanes* grew in association in pockets on the cliff faces. The rare hybrid between them, a fern new to the state, was a most appropriate find by Gerald Gastony, a new pteridologist on the staff at Indiana University.

An extra stop was made at the Martin State Forest, near Shoals, for several of the group who wanted to see *Dryopteris goldiana*.

We were especially pleased to have among the thirty-three members and guests attending the Foray, several Hoosiers, enthusiastic and knowledgeable about their flora including, Gregory Anderson, John Clements, Lynda Cole, Amy and James Mason, Jeanette Oliver, and especially James Maysilles, of Hanover College, who arranged for our comfortable lodging and a fine picnic lunch. We are much appreciative of his help and that of Rolla Tryon in guiding us to some of their favorite haunts in southern Indiana.—ALICE F. TRYON, *Gray Herbarium, Harvard University, Cambridge, Mass. 02138.*

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C. V. MORTON ROLLA M. TRYON

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American Fern Journal

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IMPORTANT ERRATUM

Due to an error on the part of the printer, the January-March, 1971, issue of the American Fern Journal was indicated at the top of the front cover, at the top of page 1, and at the right hand top corner of the plates, as being "Vol. 71." The correct volume number is 61. Please correct your copy in order to avoid problems of bibliographic citation in the future.

American Fern Journal

VOL. 61 APRIL–JUNE, 1971 NO. 2

Lindsaea (Schizoloma) ensifolia Swartz in Hawaii

W. H. WAGNER, JR.[1]

The ferns and other pteridophytes of the Hawaiian archipelago include approximately 180 species, of which 20 were naturalized since 1850, having been introduced by man (Wagner, 1948, 1963). The islands have received an enormous amount of exploration by botanists over the years, but discoveries are still being made. Today we tend to assume that all of the major indigenous genera and species groups have already been found. Nevertheless, I wish to report a wholly distinctive species of fern not heretofore collected in the islands. As will be described below, the plant in question grows in a rather unlikely habitat in association with other species which more or less resemble it.[2] The fern could be readily overlooked; in fact, it was almost an accident that we noticed it at all.

On December 16, 1969, a group of botanists and ecologists visited the Puhimau "Hot Spot," an area along the Chain-of-Craters Road in Hawaii Volcanoes National Park, just south of

[1] Research supported by NSF Project GB-8113, The Evolutionary Characters of Ferns. I wish to acknowledge the aid of Charles Cooper, J. Linsley Gressitt, K. U. Kramer, D. B. Lellinger, D. Mueller-Dombois, and Garrett Smathers.

[2] One such species is *Pteris vittata* L. Although adult plants of this species are obviously different from *Lindsaea ensifolia*, the juveniles are more difficult to distinguish. They differ in having all of their pinnae short to even orbicular in the youngest stages and in being pinnate at early stages. Those of *L. ensifolia* are ternate and perhaps even simple at early stages, and become pinnate only at later stages.—D.B.L.

Volume 61, No. 1, of the JOURNAL, pp. 1–48, was issued March 23, 1971.

Fumerole Area in Hawaii Volcanoes National Park. Fig. 1. Bleak appearance of vegetation and plumes of hot steam. Fig. 2. Observer standing near the edge of a large steam vent.

Puhimau Crater (briefly described by Doty and Mueller-Dombois, 1966, pp. 322–323). Surface and steam vent temperatures here run from 48°–89° C, and the ground is warm to the touch. The roots of many of the plants, including the conspicuous grass *Andropogon virginicus* and scattered small trees and shrubs of *Metrosideros* are only at the surface and do not penetrate into the hot earth. For this reason the plants are not anchored and can be literally moved around and re-arranged like pieces of furniture on the white, ash-like soil. Plumes of steam arise in an eerie fashion in this other-worldly habitat (*Fig. 1, 2*). Around the steam vents are dense growths of mosses and ferns (*Plate 11*). The ferns are mainly Swordferns, *Nephrolepis exaltata*, but occasional patches of *Ophioglossum nudicaule* occur among the mosses. The Swordferns tend to become progressively smaller the closer they grow to the steam, as shown in the lower half of *Plate 11*.

While we were examining the Swordferns around the steam vents we first noticed small plants that seemed especially in texture to be different from the juvenile plants of other fern species known to occur in the Kilauea area. Careful examination of these plants and their associates finally revealed older stages of this fern, which we realized was a species unreported in the islands. Colonies of it, usually vastly outnumbered by the associated and grossly similar-appearing *Nephrolepis*, were later located around several of the steam vents. Subsequently the plant was identified as *Lindsaea* (*Schizoloma*) *ensifolia*, about 2600 miles from its nearest other localities in Samoa.

In the following paragraphs comments will be made upon the leaf structure, juvenile and mature, and the significance of the occurrence of this fern in Hawaii.

The early heteroblastic stages (*Plate 12*) are different in appearance and structure from the mature stages in *Plate 13*. The earlier stages look similar to the corresponding juvenile stages of the Tree-fern *Cibotium*. But the little plants of *Lindsaea* are glabrous and much thicker-textured than those of *Cibotium*. The young stages have jagged, more or less lobed pinna margins with up to two pairs of pinnae. The veins are free, except the larger specimens

Edge of Fumerole with Progressively More Depauperate Forms of the Dominant Nephrolepis exaltata (Photograph by Mueller-Dombois).

(on the right side on *Plate 12*) which have more or less casual anastomoses. These fronds are transitional to the mature forms shown in *Plate 13*. Holttum (1954, p. 342) in his discussion of this species and its relatives comments that:

> The main evolutionary trend in *Schizoloma* [a taxon that he upholds as a genus distinct from *Lindsaea*] is towards a simply pinnate (or even simple) frond with reticulate veins and a long fusion sorus. On this view, the common Malayan *S. ensifolia* represents an advanced type . . .

It is interesting to note, therefore, that the heteroblastic series of *Lindsaea ensifolia* leaves from Hawaii seem to follow approximately Holttum's concept of the evolutionary trend in frond evolution, a possible case of recapitulation.

The largest fronds of *L. ensifolia* that we were able to find are consistently trifoliolate (*Plate 13*). Their veins are copiously netted (for details of pattern see Wagner, 1952, *fig. 24,c*). The leaf margins of the mature fronds are nearly entire. We were able to find only a few fertile fronds, and these were only incompletely fertile, with the sori interrupted and widely separated. Efforts should be made to obtain more fertile fronds in order to determine whether the Hawaiian form has consistently discrete sori.

Mature fronds were sent to Dr. K. U. Kramer of the State University of Utrecht, Netherlands, who has made extensive studies of lindsaeoid ferns in various parts of the world. In commenting on these specimens (letter, March 4, 1970), he wrote:

> It is indeed strange that only trifoliolate leaves of *L. ensifolia* have been found at the Hawaiian fumeroles. Offhand, without knowing the exact local situation, I should say that apparently the plants fail to reach a more mature stage with multijugate lamina. In what I take to have been poor habitats in the mountains of e.g. New Guinea even simple forms have been collected. In the genus *Lindsaea* it is not uncommon to find fertile leaves even in small, evidently far from full-grown leaves.

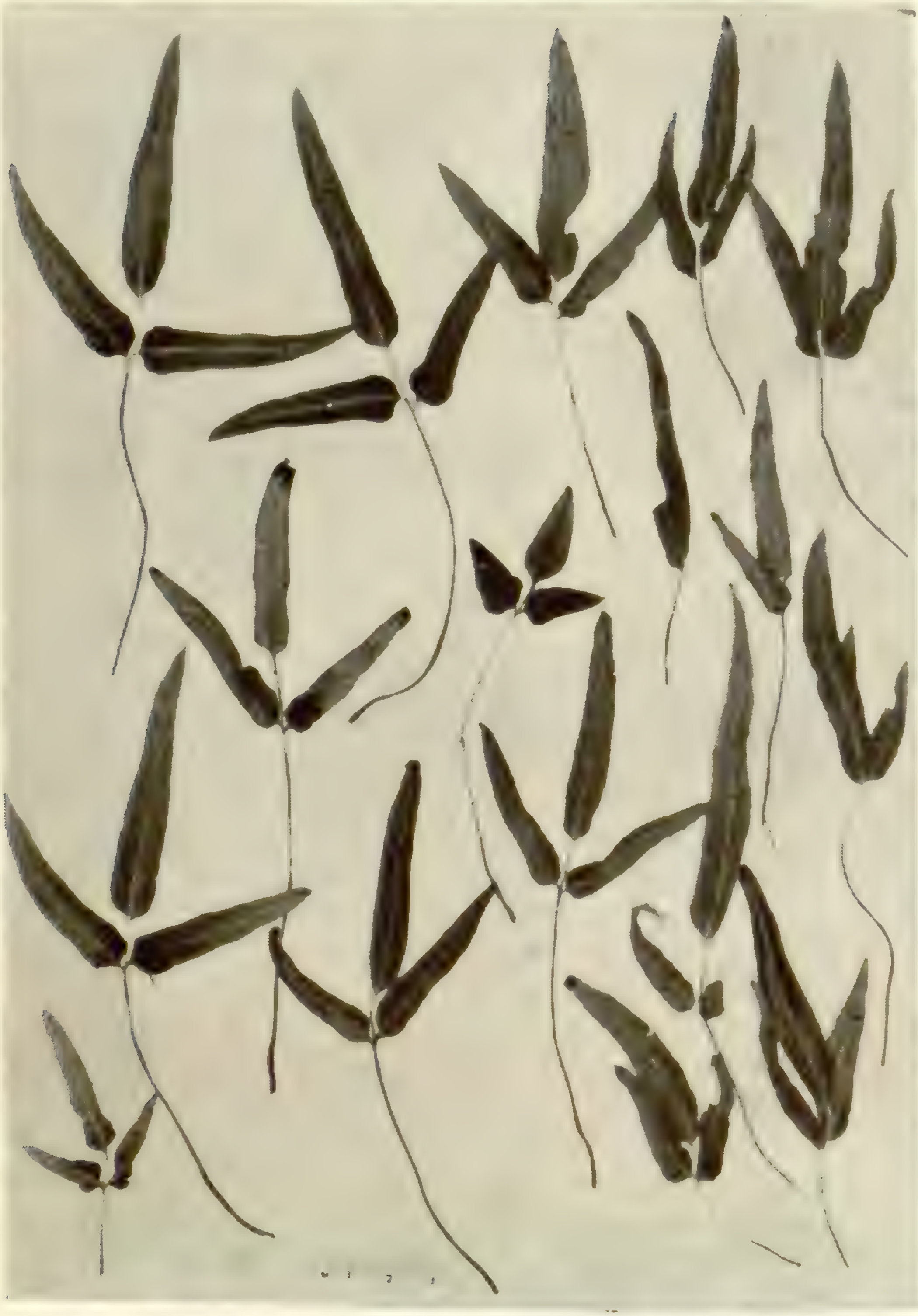
Heteroblastic Leaf Stages of Lindsaea ensifolia from Steam Vent Edges with Earlier Stages at Left.

In another communication (January 7, 1970), Dr. Kramer stated that:

> The most intriguing thing is perhaps that this is clearly ssp. *ensifolia* which has a *western* distribution (East to Micronesia and the Solomon Islands), not ssp. *agatii* which I have seen from Micronesia, Melanesia, and Polynesia (Fiji, Samoa, Tonga), which is the *eastern* subspecies. [For details of the contrasts, see Kramer, 1967a, p. 579].

As *Lindsaea ensifolia* was not encountered in Hawaii until December, 1969, one might argue that it had been introduced by man, either intentionally or unintentionally. I am, however, hesitant to accept this argument. This is not a plant likely to be carried by man. Unlike various naturalized ferns of Hawaii (cf. Wagner, 1948), *L. ensifolia* is a relatively unattractive fern and is not grown at all in horticulture, to my knowledge. The area where it occurs in the fumeroles has been studied in some detail by botanists, it is true, but the appearance of the plant is such that it can be casually confused with imperfectly developed stages of other ferns, e.g., *Cibotium* or *Nephrolepis*. It can be overlooked readily in a tangle of dwarfed *Nephrolepis* fronds (*Plate 11*). The geographical separation of the Hawaiian plants from other Polynesian localities is very large (the nearest are Samoa, Fiji, and Rotuma, according to St. John, 1954), but such large disjunctions across the open seas are not uncommon among Pacific ferns. In fact, the geographical distribution is similar to the two other lindsaeoid ferns known in Hawaii, *Lindsaea repens* and *Sphenomeris chinensis*. Fern spores are capable of long-distance dispersal because of their extremely small size. Current research suggests that a single spore has the potentiality of initiating a new colony of ferns by gametophytic self-fertilization. Fern gametophytes tend to be self-compatible according to the recent studies of Klekowski and Baker (1966).

Physically the habitat in which we found *Lindsaea ensifolia* in Hawaii is peculiar. However, *L. ensifolia* in other parts of its range is very commonly a sun fern, growing in open, lateritic savannas,



Mature Fronds of Lindsaea ensifolia from the Steam Vents, Carefully Spread out in Pressing (left) and Pressed Directly Without Spreading (right).

and capable of withstanding the heat of direct sunlight. Holttum (1954, p. 243) states that it "has the power to live in poor soil, in exposed as well as shaded places." In the Kilauea fumeroles it is associated with *Ophioglossum nudicaule*, a common associate also in the savannas of Micronesia (e.g., Guam) and Melanesia (e.g., Admiralty Islands).

The very brief list of lindsaeoid ferns of Hawaii has now been expanded from two to three. These are morphologically different from one another, but they do share rather similar, broad ranges. *Lindsaea repens* (Bory) Thwaites belongs to subg. and sect. *Odontoloma* according to Kramer, and is interpreted by him (1967b, pp. 568, 569) as being "very variable, and a number of more or less limited infraspecific categories can be distinguished." He interprets the Hawaiian plant as var. *macraeana* (Hook. & Arnott) Kramer. *Lindsaea ensifolia* belongs to subg. *Lindsaea* sect. *Schizoloma* according to Kramer (1967a). *Sphenomeris chinensis* (L.) Maxon was previously designated by most recent writers as *S. chusana* (L.) Copel., but the latter name is evidently incorrect (Kramer, 1967a; Fosberg, 1969). All three of the Hawaiian lindsaeoid ferns range as far west as tropical Asia.

Further field studies of the fumeroles of the Kilauea area are recommended to determine whether other still unreported fern species have been overlooked in these seemingly unlikely fern habitats. Outside of Hawaii, I am aware of only one previous report of a strongly disjunct fern population around hot effluents. T. M. C. Taylor (1963) reported an unusual occurrence of the southern maidenhair fern, *Adiantum capillus-veneris* L., as follows:

> In British Columbia it is known from the runnels of the hot springs at Fairmont, north of Columbia Lake. Despite the fact that the nearest known colony is some hundreds of miles to the south, there is very strong circumstantial evidence to support the view that it is indigenous at Fairmont and not an escape from cultivation.

In the Hawaiian fumeroles there is no reason to believe that the disjunct ferns reported here are not also indigenous. Now that

we know that both *Ophioglossum nudicaule* and *Lindsaea ensifolia* are found in the steam vents of Kilauea and are apparently limited to them, interest in the investigation of these unusual habitats should be stimulated.

LITERATURE CITED

DOTY, M. S. and D. MUELLER-DOMBOIS. 1966. Atlas for Bioecology Studies in Hawaii Volcanoes National Park. Hawaii Bot. Sci. Paper 2. iii + 507 pp.

FOSBERG, F. R. 1969. The nomenclature of Sphenomeris chinensis [Filic.]. Taxon 18: 596–598.

HOLTTUM, R. E. 1954. Ferns of Malaya. Gov't. Printing Office, Singapore. iv + 643 pp.

KLEKOWSKI, E. J., JR. and H. G. BAKER. 1966. Evolutionary significance of polyploidy in the Pteridophyta. Science 153: 305–307.

KRAMER, K. U. 1967a. The lindsaeoid ferns of the Old World. I. New Caledonia. Acta Bot. Neerl. 15: 562–584.

———. 1967b. The lindsaeoid ferns of the Old World. II–III. Notes on Lindsaea and Sphenomeris in the Flora Malesiana Area. Blumea 15: 545–576.

ST. JOHN, H. 1954. Ferns of Rotuma Island, a descriptive manual. Occ. Papers Bishop Mus. 21: 161–208.

TAYLOR, T. M. C. 1963. The Ferns and Fern-allies of British Columbia. British Columbia Prov. Mus. Dept. Recreation and Conservation Handbook No. 12. 172 pp.

WAGNER, W. H., JR. 1948. Ferns naturalized in Hawaii. Occ. Papers Bishop. Mus. 20: 95–121.

———. 1952. The fern genus Diellia. Univ. Calif. Publ. Bot. 26: 1–212.

———. 1963. Pteridology in Hawaii. Hawaiian Bot. Soc. Newsletter 2: 117–123.

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The Fern Collections in Some European Herbaria, VII

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BRUSSELS

There were doubtless some herb gardens in Brussels from very early times, but the first formal association of gardeners was that of the Confrérie de Sainte-Dorothée formed in 1650 and named in honor of Saint Dorothy, supposed for some reason to be the patron saint of flowers. This venerable institution persisted until the French occupation of Belgium in 1794. In 1822, a number of the former members reconstituted the society under the more appropriate name of the Societé de Flore, and it still exists today as a part of the Societé Royale Linnéenne et de Flore.

Under the French occupation the government established a botanical garden in Brussels in 1797, which was located in the grounds of the palace known as the "Ancienne Cour." This garden was intended primarily for the instruction of students in the Ecole Centrale. It had a considerable number of rare plants arranged by the Linnaean system.

In 1825, four botanists, headed by J. B. Meeus, approached the burgomaster for permission to found a company to build a new botanical garden. An area of about 15 acres in a good part of Brussels on the newly proposed Rue Royale was at that time the site of a market-vegetable garden. This was bought by Meeus for 43,537 francs. The society was formally approved by a royal decree May 28, 1826, under the name Societé Royale d'Horticulture des Pays-Bas. A competition was held for the design of a building, and that by the French painter Geneste was chosen. The building, still standing today, is a fine example of classical architecture.

The construction of buildings proceeded rapidly. The greenhouses were already finished in 1827, ready to receive the plants from the garden of the Ancienne Cour, which was being abandoned

after a disastrous fire in 1826 and the consequent reconstruction of the court.

In 1814, near the end of the Napoleonic period, the powers formed the United Netherlands under William I, but this union of the Dutch and Belgians was an uneasy one due to economic problems and the divisive influences of religion and language. The Belgians broke away in 1830 and Dutch troops sent in to quell the uprising lodged in the new greenhouses, causing great damage. There perhaps was no herbarium in the botanical garden, the only herbarium being the Rijksherbarium, at that time in Brussels under the directorship of Blume. When the Dutch withdrew in 1830 they took along the state herbarium to Leiden, where the Rijksherbarium still is, a circumstance that shows how much herbaria may be valued even in times of war and stress. Later, the new king of the Belgians, Leopold I, of Saxe-Coburg, gave the garden the collections of herbarium specimens that belonged to the royal court. After the independence of Belgium, the name was officially changed to Societé Royale d'Horticulture de Belgique.

The new garden was financed by the selling of shares, for which the stockholders were to receive dividends. The city and government agreed to a subsidy, but the amount was small, and so the only way that the society could make money was by the sale of plants. Thus almost by necessity the garden was forced to have plants that would grow easily in Brussels and which would sell well, and this consequently led to the neglect of strictly botanical work. Even so, severe financial troubles in 1841 caused a move to dissolve the society, which was in debt for over 203,417 francs. The salvation of the botanical garden was mostly the work of one of the giants of Belgian botany, Barthélmy Charles Joseph Du Mortier. He was born in Tournai April 3, 1797. He did not receive any formal training in botany, but nevertheless devoted himself to it wholeheartedly from about the age of 19, when he began collecting plants in 1816. He married also at the age of 19 and was devoted to his wife, by whom he had eight children, for the next 60 years. He must have had independent means and some social status because he worked independently studying and

writing on botany until 1831, at which time he was elected to the Chambre des Représentants, the equivalent of our House of Representatives. He continued to be reelected for the next 47 years until the time of his death in 1878 at the age of 81.

In the early nineteenth century the Linnaean system was still dominant but that of Jussieu was gaining adherents. Du Mortier considered the Linnaean system analytical and that of Jussieu synthetic, and he wished to amalgamate them, an idea that seems rather impossible on the face of it. However, as Crépin remarked, because of his lack of training he did not hesitate to discuss the most difficult problems in botany and zoology. When he was 24, Du Mortier personally published his "Commentationes Botanicae" (1822), in which some of his ideas were expressed, a book that is said to have caused a sensation in Belgian botanical circles. The part that is remembered now is the last chapter, in which the old cumbersome genus of hepatics *Jungermannia* was broken up into several, a view that is certainly now considered correct. Du Mortier's work was original, and he was doubtless much disturbed to find out in 1831 that Raddi had anticipated him by publishing a similar segregation of *Jungermannia* in an obscure Italian publication in 1820. Nevertheless, he continued working on hepatics, publishing his "Sylloge Jungermannidearum Europae" in 1831 and more than 40 years later the complete monograph "Hepaticae Jungermannidearum Europae" (1871).

Du Mortier worked also on phanerogams, especially Scrophulariaceae, *Batrachium*, *Salix*, and Gramineae. His "Florula Belgica Prodromus" (1827) was intended as the forerunner of a complete flora of Belgium, something not in existence then, but he never finished this. Before writing this, Du Mortier visited the Linnaean Herbarium, then in London in the custody of Sir James Edward Smith, to study types, one of the rather few early botanists who availed themselves of this privilege. At the same time he also made an expedition to Scotland to see the elder Hooker. [In 1826, a trip to Scotland probably really deserved the term "expedition."]

At the International Botanical Congress in Paris in 1867, Du Mortier presided at the sessions on nomenclature, the

principal interest of the Congress and one that took up over half of its time. In 1872 he was made a count by Léopold II. The medal struck for him has below the portrait the words "Felix qui potuit rerum cognoscere causas" [Happy is he who can know the causes of things]. On his 81st birthday in 1878, his statue was unveiled in the botanical garden, a bust that is still there in a place of honor.

Du Mortier, as commissioner in charge of scientific establishments, was able to persuade the government to double its subvention of the botanical garden, provided that the society would renounce its right to dissolution without the consent of the government. The society was authorized to sell some of its grounds on the side of the present Gare du Nord in order to pay its debts. A period of prosperity then began, especially after H. G. Galeotti was selected as Director in 1853.

Henri Guillaume Galeotti was born September 10, 1814, in Paris, France, of Italian parents. He was educated as a geologist, and published something on the geology of the region of Brabant at the early age of 20. This brought him to the attention of the Vandermaelen Brothers, the proprietors of a geographical institute and museum in Brussels. They sent him in September, 1835, to Mexico to study the geology and to collect plants, both living and dried, which Galeotti did vigorously, assembling more than 8,000 numbers of herbarium specimens in five years. He began his collecting in the rich region of Mirador and Jalapa in Veracruz. He was perhaps the first botanist to climb the high mountains Orizaba and the Cofre del Perote. In July, 1836, he collected in Real del Monte, Hidalgo, with the German botanist C. Ehrenberg. The next three years were spent on the plateau of Mexico and in the west. In 1839 he went to the southern state of Oaxaca, where he obtained his richest collections. Before returning to Europe in 1840, he established a botanical station in Mirador which was used by later collectors.

On his return to Belgium he was made Administrator of the Societé Royale de Flore and later editor of the Journal d'Horticulture Pratique. He lived in Louvain, where he became a natu-

ralized Belgian in 1843. His wonderful collections were studied by some of the foremost botanists of the time, the cacti by Lemaire, the grasses by Trinius, and the orchids by Achille Richard. Many of the ferns and phanerogams were published on by the Professor of Botany in Louvain, Martin Martens (1797–1863). Galeotti himself although sometimes a co-author seems not really to have been himself a taxonomist.

Unlike most early collectors, Galeotti collected many duplicates and sold them widely, and so they are in most of the large herbaria. Dr. R. Tournay, documentation chief in Brussels, tells me that the Galeotti specimens belonging to Martens were held by the Martens family until 1932, when Pierre Martens, greatgrandson of M. Martens, gave them to Brussels. However, the "Index of Collectors" of the "Index Herbariorum" (Regn. Veg. **9,** II(2): 214. 1957) indicates that the original and largest set (7,000 specimens) isstill in Louvain, which is a matter that ought to be looked into. Galeotti collected only in Mexico and a few specimens in Cuba but is often cited as the collector of plants from Brazil, Venezuela, and Colombia, but these plants were actually collected by Linden, and Galeotti was merely the distributor of the Linden plants. In 1853, he was appointed Director of the Jardin Botanique de Bruxelles, a post that he retained until his death from tuberculosis in 1858 at the age of 44, a relatively early age considering that as a group Belgian botanists seem to be exceptionally long lived. During his administration an herbarium was started with Galeotti's own collections as a basis, to which were added those of Linden, Funck, Schlim, Ghiesbreght, Lindig, and the complete Brazilian herbarium of Peter (laussen. The botanical library was also enlarged.

After the death of Galeotti, A. J. Schram became the Acting Director, and J. E. Bommer was appointed as conservateur (curator). Mr. Schram may not have had the best judgment. The erection of an aquarium was a costly mistake. When Schram left, Bommer was apparently the Acting Director. The necessary replacement of the heating equipment in 1862 caused some financial embarrassment, so that again the stockholders received no dividends. The administration tried without success to get additional

subsidies from the city and government. In 1865, the garden had tempting offers of up to 6,000,000 francs for permission to allow roads to run through the garden, and so there was again a determined move to dissolve the society. Again Du Mortier, who was still powerful in the government, came to the rescue. He persuaded the government to buy the garden for 1,000,000 francs, not a large sum even at that time for such a valuable property. However, it was doubtless large enough for the shareholders to receive their equity. The garden was then renamed the Jardin Botanique de l'Etat [in Flemish, the Rijksplantentuin], a title that it retained until 1967, when the name was changed for some unexplained reason to the Jardin Botanique National de Belgique [Nationale Plantentuin van Belgie].

The official establishment of the Jardin Botanique de l'Etat in 1870 was followed a year later by a most propitious occurrence. The famous Bavarian botanist Karl Friedrich Philipp von Martius (1794–1868) had assembled a very large private herbarium, in excess of 113,000 specimens, which was offered by the family to the government of Bavaria for purchase, but the government very short-sightedly refused, because it had already the Brazilian herbarium of Martius and Spix. The family therefore wrote to Anton Spring, the monographer of *Lycopodium* and a former student of Martius, who formed a committee consisting of himself, Alphonse De Candolle, and August Eichler. De Candolle wrote a flattering letter to Du Mortier, ending: "J'ose insister, parce qu'il est bien rare qu'un Président de Societé botanique et un botaniste consommé soit en même temps un politique d'un pays. Ce sont des conjonctions aussi rare que celles de certain corps célestin. La Science doit en espérer beaucoup." Du Mortier was persuasive as usual and the Belgian government purchased the Martius Herbarium in 1870 for 32,000 francs, a ridiculously small sum even for those days for an herbarium containing thousands of types and unique specimens. The herbarium was delivered to the state botanical garden in 1871, where it forms the real basis today of the general herbarium. The collections in this herbarium, which were enumerated by Eichler in his paper on the Herbarium

Martii, are far too numerous to list here. They include historic specimens from all parts of the world.

The state garden has had very few Directors since its establishment a century ago, principally Crépin (1876–1901), Durand (1902–1912), De Wildeman (1912–1931), Walter Robyns (1931–1966) and Fernand Demaret (1966–present). After Provisional Directors Bommer and Dupont, François Crépin was appointed Director in 1876. Crépin was the antithesis of Du Mortier, not a politician and outgoing public figure but a retiring man content with his work with plants. He was born in Rochefort, October 30, 1830, and never received a degree or any formal training in botany. While he was working as a postman at the age of 18 he began botanizing in his spare time, and at 20 quit the post office to devote himself wholly to botany without any sponsor or any hope that he would ever have an official position. For the next ten years he collected and studied the plants of Belgium, and his resulting book, the "Manuel de la Flore de Belgique" published in 1860 immediately established his reputation. Because of its compact size and keys, the work went through several editions and enlargements and was the standard field-guide for two generations of Belgian botanists.

His friendship with Louis Van Houtte stood him in good stead. Van Houtte had been employed in the Ministry of Finance. However, when one day he was requested to undertake an important mission over the week-end he replied that it was impossible since he had a date to see the flowering of a rare cactus. The reply did not please the Minister, and from then on Van Houtte was free to devote himself wholly to observing plants, something indeed fortunate for botany since he became one of the foremost protagonists of horticulture and botany in Belgium and indeed in all of Europe.

In September of 1861, Michel Joseph Scheidweiler (1799–1861), then in the Institut Horticole of Gentbrügge, died leaving vacant the chair of botany and agronomy that Planchon had for a time occupied. Van Houtte was able to get Crépin this professorship which meant that Crépin immediately had to improvise courses in botany, a task that he did creditably. However, he had little

interest in garden plants, and Van Houtte's continuous importunities to name his greenhouse plants caused a break in their friendship. Therefore, Crépin left Ghent in 1871 to become the curator of the paleontological section of the Musée Royal de l'Histoire Naturelle de Bruxelles. The government had purchased a collection of plant fossils from E. Coemans, and Crépin was delegated to name them. In 1872 he was elected to the Académie des Sciences de Belgique and in 1876 became the Director of the Jardin Botanique de l'Etat.

The staff near the beginning consisted of Bommer, Cogniaux, and Marchal, to which were added sometime later Delogne, T. Durand, and De Wildeman, a distinguished staff indeed. The working room was at the time the large room now containing some offices at the sides and a wood exhibit in the center. Crépin sat in the middle at a big table on a dais where he could survey the work of his staff. On his left at the most primitive kind of tables barricaded by stacks of books and cartons of herbarium specimens sat Bommer, Elie Marchal, and the bryologist Charles Delogne, and on the right Sonnet, Vindevogel, Lubbers (the Head-Gardener), and T. Durand. De Wildeman, as only a volunteer at this time, sat in 1887 at a table a little to the rear. Working conditions must have been difficult, for at first there was no illumination other than the natural light from the windows, and Brussels is not notably bright during the long winters. Only in later years was gaslight installed. Yet the amount of work accomplished was enormous. Crépin himself worked on the genus *Rosa*, a task on which he spent 40 years, and on which he published over 1,500 pages, but even so his work was never fully completed. His rose herbarium of over 40,000 sheets is kept today as a special unit.

Crépin retired because of poor health in 1901 and died in 1903. He was described on a field-trip in 1893 by a journalist as a vigorous sexagenarian, a confirmed bachelor, with a voice sweet and low, who looked like a retired army major except for his modest and reserved attitude, always with his eyes on the ground as if looking at something [which does not seem at all strange to a botanist]. A statue of him was erected in 1904 in his birthplace in Rochefort

in the square named in his honor, the Place François Crépin. For a portrait of Crépin see the biography in Bull. Jard. Bot. de l'Etat Brux. **1**: 281–317. 1905. Fascicle 2 of volume 9 of the same journal is devoted to the celebration of the centenary of Crépin's birth.

Two of the staff members deserve special mention. Célestin Alfred Cogniaux (1841–1916) was born in Robechies. He was appointed Aide-naturaliste in 1872 in the newly organized Jardin Botanique de l'Etat, where he remained for a number of years. He was a prolific worker on three difficult plant families, writing the Cucurbitaceae (1878), Melastomataceae (1883–1888), and Orchidaceae (2037 pp., 1893–1906) for Martius' "Flora Brasiliensis," and the Cucurbitaceae (602 species, of which 221 were new, 1881) and the Melastomataceae (2,730 species, of which 792 were new, 1891) for DeCandolle's "Monographiae Phanerogamae." Finally in his later years, 1909–10, he published an account of the orchids of the West Indies in Urban's "Symbolae Antillanae." His valuable herbarium was sold to Brussels.

Elie Marchal was born March 1, 1839, at Wasigny, France, of Belgian parents. In 1871, he was chosen by Bommer as Aide-naturaliste in the Jardin Botanique de l'Etat, where he worked on mosses and fungi. He was in charge of the plantings in the garden, where he established sections for ornamental plants, edible plants, medicinal plants, and plants of technological importance, all these in addition to the plants of primarily botanical interest. This was in opposition to some prominent Belgian botanists like Kickx, Morren, and Martens, who wanted only plants of botanical interest. He was ahead of his time in insisting that all the plants were properly ticketed with their names and acquisition data. In his later years he worked on Araliaceae, and prepared the account of this family for the "Flora Brasiliensis." For reasons of poor health he retired in 1899, but nevertheless lived up until 1923, when at the age of nearly 84 he was still interested and working on sexuality [of the mosses].

The next Director was Théophile Alexis Durand, one of Belgium's outstanding botanists, who was born in 1855 in St. Josse ten Noode. He explored the region of Liège and published

his first paper on the flora in 1874 at the age of 19. At the suggestion of Elie Marchal he went to Switzerland in 1877 to study the alpine plants, and published a series of papers (1881–1887) with his friend Henri Pittier, at that time Professor of Botany at Chateau d'Oex. In 1879 he started work as a volunteer in the Jardin Botanique de l'Etat. By his continuous work and the care he gave to all the tasks confided to him he won the regard of Crépin and was appointed to the staff as Aide-naturaliste in 1881, and later became the curator. At first he worked on the bryophytes of Belgium with Delogne, but soon became interested in compiling an index of genera, the result being the "Index Generum Phanerogamorum," a work that made him famous and one that is still most useful to the herbarium botanist. He then collaborated with B. D. Jackson in preparing the first supplement to the "Index Kewensis." In the meantime he continued floristic work with Pittier on the "Primitiae Florae Costaricensis." In 1895, at the request of the government, it was decided that the garden should undertake the study of the flora of the Belgian Congo, and Crépin delegated Durand and De Wildeman to the task. This collaboration resulted in the formation of the "Annales de Musée du Congo" and the publication of many important papers on the plants of that region until eye trouble forced his retirement in 1908. He died in 1912.[1]

The next Director, one of the brightest lights of Belgian botany, was Emile De Wildeman, who was born in Brussels, October 19, 1866, where he died July 24, 1947. He became a volunteer worker in the botanical garden in 1887 and was taken officially on the staff in 1890, where he remained for 41 more years of service before retiring in 1931. At the time he was one of the first students of the famous professor Léo Errera (the formulator of what is called "Errera's Law" that a cell membrane tends to assume the same form as a weightless fluid layer would assume under the same conditions), who had just started a botany department in the

[1] For a biography by De Wildeman, see Bull. Jard. Bot. de l'Etat Brux. 4(2): i—xvii. 1914. This Durand is not to be confused, of course, with the American Elias M. Durand, whose historic herbarium containing Rafinesque types is now in Paris.

University of Brussels in 1891. De Wildeman received his doctorate in 1892 with a thesis on cell division. In his early years he worked and published on algae, but in 1895 Crépin decided to charge him with the preparation of a flora of the Belgian Congo, a task on which he spent the rest of his life. The herbarium collections that had been accumulated by the Etat Independant du Congo were turned over to him, the beginning of the present tremendous collection of Congo plants numbering more than 500,000 sheets in 1948. De Wildeman became the foremost authority on the flora of the Congo, and was very likely the last botanist to describe thousands of new species [because there are no more completely unknown parts of the globe]. It was perhaps not necessary to describe quite so many, because recent studies have shown that De Wildeman did not always take into account the species that had been described from other parts of tropical Africa, and also had perhaps too narrow a species concept, but even so most of his species are good ones. He was one of the most prolific workers ever, with a bibliography of more than 1,400 titles, ranging from brief notes to large books. His final work, entitled rather sadly, "Stérilité ou Viellissement et Disparition des Espèces Végetales" was published in two volumes a year after his death at the age of 80 in 1947. He was the Secretary-General of the International Botanical Congress that was held in Brussels in 1910. In 1912 he became Director of the Jardin Botanique de l'Etat." Young botanists and perhaps especially the old too) should ponder his words: "Ne cherchons pas à faire oeuvre définitive! Ne nous berçons pas du fallaceiux espoir de produire des travaux sans défauts. La perfection n'est pas de nôtre monde!"

During the regime of W. Robyns, the next Director, it became apparent that the old building and greenhouse were inadequate and that the garden was suffering from the city air. It was therefore arranged in 1938 that the garden be moved to the Domaine de Bouchout, in the country near Meise, a few kilometers north of Brussels. This is a large estate of over 200 acres, with a lake and an imposing chateau, formerly a royal residence. The advent of

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[2] For a biography, see Bull. Jard. Bot. de l'Etat 19: 1–31. 1948.

the war in 1939 naturally stopped any move to the new quarters. About 10 years later work was started, and now the huge greenhouses are finished and all the plants moved from the old ones. A magnificient new administration and herbarium building is awaiting occupancy. The new garden is not so accessible as the old one in the center of Brussels, but is well worth a visit. In addition to the greenhouses the grounds themselves contain many fine old trees dating back a century or more. Certain areas are being left in a natural state for the wild vegetation. The new garden may be reached rather easily by taxi or bus. There are however, I believe, no accomodations nearby where visitors can stay for longer periods.

Robyns continued with De Wildeman's work on the Congo, publishing volumes on the grasses and a "Flore des Spermatophytes du Parc National Albert" in three volumes (1948–1955). He also started the publication of the "Flore de Congo Belge et du Ruanda-Urundi," of which ten volumes appeared between 1948 and 1963. This work is being continued, but now in the form of separate fascicles for the different families, which can thus be issued as they are ready without any set taxonomic sequence.

The present Director, Fernand Demaret, an authority on the bryophytes of the Congo, first came to the garden in 1936 as an assistant and became director in 1966.

September 1970 being the centenary of the establishment of the garden as a government unit, the garden held a formal celebration of the event. Botanical institutions throughout the world were invited to send representatives for the ceremonies. Since I had been in Brussels in June of that year, I did not feel that I could attend, but I understand that the event was highly successful in every way.

FERNS IN BRUSSELS

The principal pteridologist in the early years was Jean Edouard Bommer, who was born November 17, 1829, in Brussels. He had no formal education in botany, but was a hard and dedicated worker, at first employed in the Etablissement Vandermaelen,

but by 1856 he was well enough known that he joined the staff of the botanical garden in Brussels as Aide-naturaliste, and after Galeotti's death he was the curator and later Provisional Director. Although Bommer worked on various groups of plants, he was mostly interested in ferns. His first paper was on the hairs of ferns, a subject that has been somewhat neglected but now realized to be of fundamental importance (Bull. Soc. Roy. Bot. Belg. vol. 1). His most important paper is the "Monographie de la Classe des Fougères," which is not a monograph but a paper on fern classification that is little known today. However, Bommer's classification was essentially that adopted by Eichler and later by Engler, and is thus quite similar to the classification adopted still later by Christensen, except for the inclusion of the Cyatheaceae in the Polypodiaceae. He collaborated with the Swiss botanist H. Pittier in publishing on the numerous then recent collections in Costa Rica of Pittier, Tonduz, Biolley, and others, in Durand and Pittier's "Primitiae Florae Costaricensis." At the time of his death February 19, 1895, he was working on a monograph of the genus *Adiantum*. According to Dr. Lawalrée, the manuscript has disappeared. Strangely enough, however, a synopsis of the proposed classification, in Bommer's own hand, is in the Smithsonian Institution, a Xerox copy of which has now been deposited in Brussels. Bommer can not be accounted an outstanding pteridologist, but his influence is clearly evident in the Brussels herbarium, where his annotations are on many sheets, and where many of the older specimens in the general herbarium are still arranged as he left them.[3]

Among the valuable parts of the old fern collections is the fern herbarium of Peter Claussen, but it seems that little is known of Claussen or his collections. It may be surmised that Linden and Claussen knew each other, since they were in Brazil at the same time. Galeotti must have been close to Linden, and through him with Funck and Schlim, Triana, and Lindig, for all these collections were turned over to Galeotti for the garden and for distribution. Thus Brussels is very rich in these old collections, especially those

[3] For a biography, see Léo Errera, Bull. Soc. Roy. Bot. Belg. 34: 7–21. 1895.

from Venezuela and Colombia that formed the basis of G. Mettenius' treatment of the ferns in Triana and Planchon's "Prodromus Florae Novo-Granatensis" (Ann. Sci. Nat. [Paris] V, **2**: 192–271. 1864). The specimens in Brussels with the names in the hand of Mettenius should be considered the holotypes. These collections are partly represented by duplicates or fragments in the Mettenius Herbarium in Berlin.

The Linden ferns are of particular importance. Jean Jules Linden was born in Luxemburg in 1817. At the age of 18 he was authorized by the Belgian government to collect plants in tropical America with Nicholas Funck and Auguste Ghiesbreght as companions. They first went to southern Brazil. On the second trip Linden went alone to Cuba in 1837, and in 1838 to Mexico and Guatemala, where he obtained sizeable collections, especially in Tabasco and Chiapas. His third and most profitable trip was made with Louis Joseph Schlim in 1841 to Venezuela and Colombia, where he remained until 1844. In 1844–1845, Linden collected extensively in Cuba, especially in the eastern province of Oriente. On his return he established a nursery in Luxemburg in 1845, which was moved in 1851 to Brusseis, where it became one of the foremost in Europe. In 1852 or 1853 he was appointed Director of the Jardin Royal de Zoologie et d'Horticulture de Bruxelles. Linden listed his offerings in catalogues that are rare and much prized today because they contain the original descriptions of some of the plants that Linden introduced to cultivation. In 1870 he expanded his establishment by buying the large nursery of Ambroise Verschaffelt in Ghent. Linden's collections were never completely worked up, although some groups were studied, e.g. the "Orchidaceae Lindenianae" by J. Lindley. Linden sold his plants widely. There is a large set in Brussels, and an unexpectedly large set in the Webb Herbarium in Florence. Linden remained active until the age of 80, when he died in 1898, at the time the Consul-General in Belgium for Colombia. There is an account of his itineraries in Annales Soc. Roy. Agr. Bot. Gard. **2**: 205–220, 259–272. 1846.

Linden's associate, Nicholas Funck (1816–1896), was also born

in Luxemburg. He was sent to Mexico with Linden in 1835 to collect, and in 1845 he went with Schlim to Venezuela and Colombia, where he assembled large and valuable collections. Unfortunately many of these were lost in a shipwreck, but even so there are some 4,650 numbers of his collecting in Brussels.

A collection of ferns of great importance is the Indian and Malaysian collection of William Roxburgh. I expect to publish a paper on the Roxburgh ferns, and so I shall not comment on them here other than to say that the Brussels set is the most authentic, with the names in Roxburgh's own hand.

The Costa Rican ferns of Pittier, Tonduz, Biolley, Wercklé, and others were worked up by Bonmer, and later by the Swiss botanist Hermann Christ. Many of the Christ types from Costa Rica are in Brussels rather than in the Christ Herbarium, now in Paris.

It is evident that when J. G. Baker was working on his account of the Cyatheaceae and Polypodiaceae for Martius "Flora Brasiliensis" (vol. 1, no. 2. 1870), that he had on loan the Brazilian specimens from Martius' herbarium, for they are annotated by Baker and correspond with the names as used in the Flora. In the case of the new species therefore Baker's types are in the Martius Herbarium in Brussels and not at Kew, where Baker's other types mostly are. Sometimes Baker removed fragments and these are at Kew. The types of Johann Wilhelm Sturm (1808–1865), who wrote the accounts of the Hymnophyllaceae, Gleicheniaceae, Marattiaceae, Ophioglossaceae, Osmundaceae, and Schizaeaceae for the "Flora Brasiliensis," are also in the Martius Herbarium in Brussels.

The holotypes of the species described in 1824 by H. A. Schrader from the Brazilian collections of the Prince von Neuwied are also in the Herbarium.

Martius lent his Brazilian collections to Gustav Kunze, the noted pteridologist of Leipzig, who published his paper "Filices in Martii Herbarium Florae Brasiliensis" in 1839. These specimens were returned to Martius, and thus the holotypes of these Kunze species are still in existence, with the names in Kunze's hand, fortunately, since Kunze's own herbarium was destroyed in Leip-

zig during World War II. Many of the South African species described by Kunze have also authentic material named by Kunze in Brussels.

The other fern collections include those of Pohl, Karwinski, Blanchet, Luschnath, Glaziou (many numbers), Husnot, Gay, Bertero, and others far too numerous to mention. Naturally, Brussels is the richest herbarium for Belgian ferns, and those of France are well represented, due especially to the fine herbarium of J. Callé and his collaborator E. Walter.

Brussels is now fortunate in having pteridologists again for the first time since the late nineteenth century. The Director, F. Demaret, is interested in the ferns of the Congo. Dr. A. Taton also has studied African ferns and has published an account of the Congo Hymenophyllaceae. Dr. André Lawalrée, the present pteridologist, prepared a perceptive account of the ferns for the "Flore Générale de Belgique" (1950) and is now at work on the ferns of the Congo, of which six parts have been published in the "Flore du Congo, du Rwanda et du Burundi," the Equisetaceae, Psilotaceae, Actiniopteridaceae, and Parkeriaceae in 1969, the Schizaeaceae in 1970, and the Blechnaceae in 1971. Collaborators preparing manuscripts include Kramer (Lindsaeaceae), Launert (Marsileaceae), Bizarri (Selaginellaceae), and Pichi-Sermolli.

I have visited Brussels three times, the first in 1954 to study and photograph the types of Martens and Galeotti. Prior to 1842, when their "Mémoire sur les Fougères du Mexique" was published by the Académie Royale de Bruxelles, very few ferns of Mexico were known. Martens and Galeotti described many new species, and they could have described more, for many that they identified with older species of the West Indies or South America proved to be wrongly identified and actually undescribed at the time. However, sometimes the Martens and Galeotti species belong to very critical groups and they can be known definitely only by the study of the original specimens. Many of the new species have proved to be common, but others have perhaps never been found again. There are many duplicates of the Galeotti collections in Brussels, but it is usually possible to tell which one is the holotype.

In my visits to Brussels I have always been most hospitably received, in 1954 by Dr. Robyns and Dr. Lawalrée, and in 1969 and 1970 by Dr. Demaret and again Dr. Lawalrée. Unfortunately, the ferns along with the general herbarium, including the Martius Herbarium, are now kept in a basement that is not well illuminated and possibly at times too damp. It is to be hoped that they can be moved soon to the new herbarium building that is ready for them.

Much of my information comes from the paper by J. E. Bommer "Notice sur le Jardin Botanique de Bruxelles," which was written at the time when the present garden was first formed (Bull. Soc. Roy. Bot. Belg. **9:** 418–455. 1871). Some of the recent information comes from the publication that was issued last year for the centenary "Le Jardin Botanique National de Belgique, 1870–1970," which is unsigned, but is by Dr. Demaret, Dr. Lawalrée, and their associates.

(To be continued)

An Appendageless Psilotum. Introduction to Aerial Shoot Morphology

ALBERT S. ROUFFA[1]

Over forty years ago Okabe (1929) wrote that . . . "*Psilotum nudum*, which grows wild in southern Japan, was once much cultivated in Japanese gardens as an ornamental plant. Slightly over 100 garden varieties were given fantastic names. Today, however, there are unfortunately only a few of them found occasionally in greenhouses of botanical gardens or in private gardens." Since the time that Okabe wrote this apparent epitaph there have been several attempts by *Psilotum* growing associations in Japan to revive the almost lost art and to gather information on the remaining varieties available. According to a special

[1] Supported by a grant from the University of Illinois, Chicago Circle Research Board.

Fig. 1. A distal portion of an aerial shoot with five branches of varying lengths bearing terminal synangia, the latter with more than the typical three locules, × 3.0. Fig. 2. A pseudodichotomy, both branches tipped with multiple synangia, the left bearing two visible stub-branches, × 3.0.

issue in December 1967 of "Horticultural Magazine" (Japan) entitled "Classical Horticultural Plants" there are about 50 clearly identified old varieties of *Psilotum* plus about 10 unidentified and newly introduced varieties in existence.

Among the older clones which may have been grown for more than 200 years there is one known as *sei ryu kaku*, a descriptive appellation that may be broadly interpreted in the traditional sense as "Green Dragon's Horns" or in a more modern sense as "Green Giraffe's Horns" (Rouffa, 1968). With all apologies to Okabe, the name, far from fantastic in this instance, appears rather appropriate (see *Figs. 1–8*). It is interesting to note that this *Psilotum* does not produce either sterile or fertile appendages and develops meiotic synangia at the tips of the ultimate branches. For this reason, this *Psilotum* merits an introduction and further study.

The clone was introduced into the United States in 1956 by Dr. John Creech (1957), of the New Crops Research Branch, U. S. Department of Agriculture, Beltsville, Maryland as P.I. 235301 and, along with a number of other Japanese Psilotums, deposited and grown for a number of years at Longwood Gardens. Subsequently, some of the collection (not including this clone) was sent to the New York Botanical Garden. I am particularly indebted to Dr. Donald Huttleston of Longwood Gardens for the special propagation and donation of their Psilotums to our department in November 1967. Up to that time the unusual characteristics of *sei ryu kaku* were quite unknown to any of us until the plants were unpacked in our laboratory.

I am also especially grateful to Mr. Kaname Kato, an eminent horticulturist in Tokyo, for providing me with valuable information regarding this particular clone and the history and culture of Japanese Psilotums in general.

MATERIALS AND METHODS

Severed shoot tips were treated in a number of ways for observation with the Cambridge Mark II stereoscan SEM (see figure legends) and included preservation in both glutaraldehyde and

Fig. 3. A distal portion of an aerial shoot with a series of branches of various lengths: Two lengths of stub branches and a terminal pseudodichotomy with short branches terminating in synangia, × 2.0.
Fig. 4. An overall view of a group of synangia-bearing and sterile aerial shoots, × 0.8.

in FAA. A study is continuing to determine the best treatment for various conditions. Fresh tips could be observed for periods up to thirty minutes, when vacuum-induced shrinkage became apparent.

Psilotums have been grown in our laboratories for a number of years indoors under fluorescent lights. They appear to grow best and produce more sporangia when cool-white lamps are supplemented with wide-spectrum Gro-Lux lamps in a ratio of 2:1. Light intensities range from 1,000–2,500 ft-c. *Sei ryu kaku* has responded well to this lighting and grows as vigorously as many of the typical Psilotums. Despite the nearly constant cultural conditions, all Psilotums tend to alternate periods of rapid growth with periods of quiescence.

OBSERVATIONS

When aerial shoots of *sei ryu kaku* emerge from the soil they appear relatively smooth and terete. Their often apiculate apex is unobscured by leaf primordia. Therefore one can easily observe the subdividing of the apex into multiple apices (Bierhorst, 1954) often when the shoot is not more than 2 cm in length above the soil (*Figs. 10, 11, 13*). After its formation, each apex eventually develops its own subtending axis before the final elongation of the total aerial shoot takes place (*Fig. 9, 11*). The shoot apices continue to subdivide following elongation of the total shoot (*Figs. 13, 14*). The early subdividing of the emerging aerial shoot apex is synchronous and symmetrical (*Fig. 13*), but the final subdivisions of the apices appear to be less synchronized and some may be quite asymmetrical (*Figs. 14, 15*). This asymmetry is perpetuated in the growth of some of the distal branches. As a result, distal shoots may develop monopodially and produce lateral branches ranging in size from mere ridges, to stub-branches 1 mm in length, to nearly equivalent pseudodichotomies (*Figs. 1–5*). Equal pseudodichotomies may also develop (*Fig. 9*). Unequal branches are often, but not always, the hallmark of shoots forming synangia (*Figs. 1–8*).

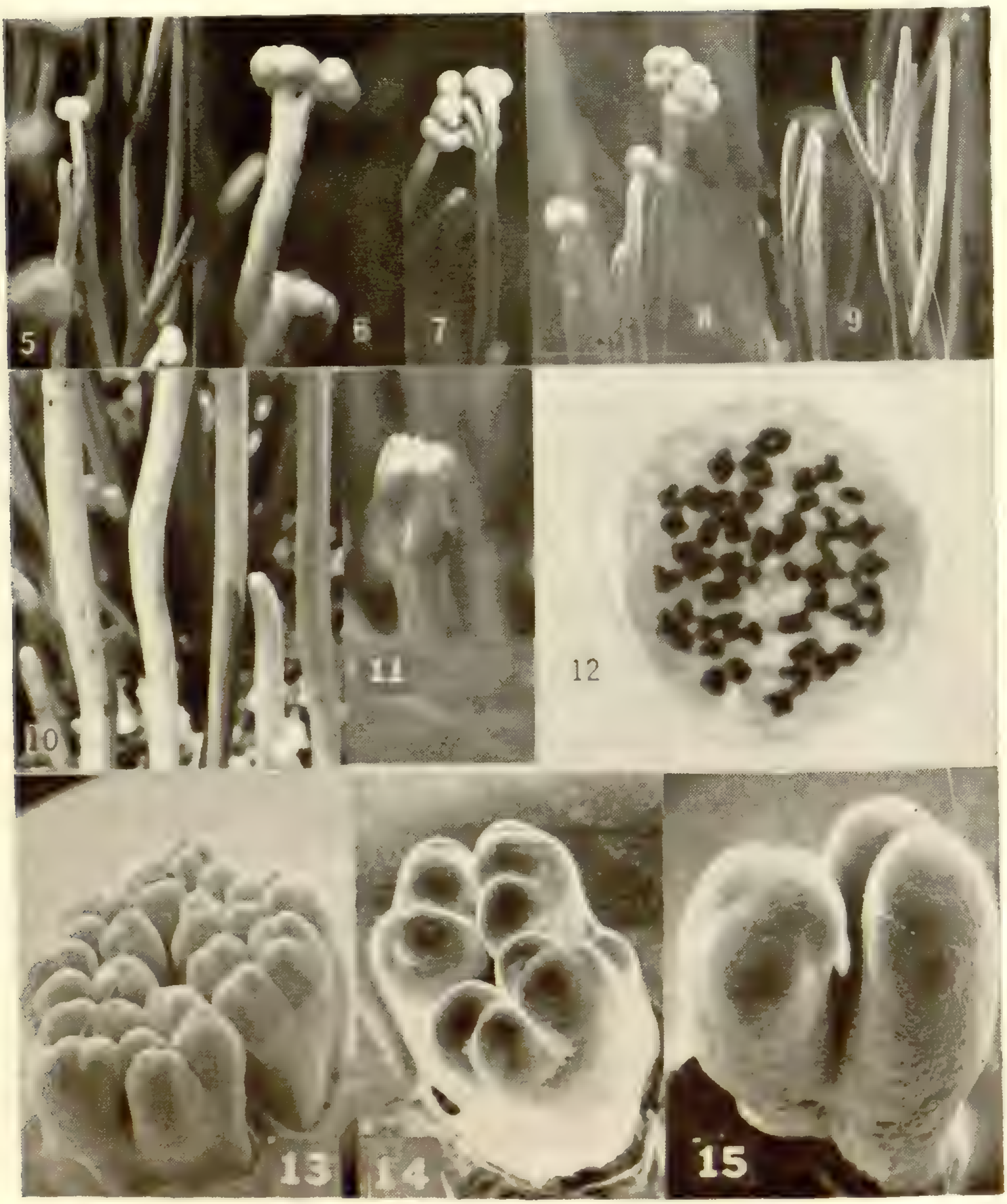

Fig. 5. Shoot terminating in sterile forked-tipped branch and a synangial branch; glistening dots on surface are stomate sites, × 1. Figs. 6–8. Shoots terminating in short synangia-bearing pseudodichotomies. Figs. 7 & 8. Same shoot taken on opposite sides. Fig. 6, × 3; Figs. 7, 8, × 1.5. Fig. 9. Actively elongating vegetative upper shoots; note the absence of appendages, × 1. Fig. 10. Basal part of shoots near ground level; note absence of sterile-appendages and the naked

The stub-branches are suggestive of the sterile appendages of the typical leafy form of *Psilotum*. On the whole, shoot vascularization of *sei ryu kaku* appears similar to that of the typical form. Freehand sections taken at suitable intervals along the shoot and stained with HCl-Phloroglucinol reveal that the stub-shoots have a lignified strand branching from the stele extending at least to their base. Those stub-shoots bearing synangia are supplied with a lignified strand to the synangium. In certain respects, particularly in their vascularization, the sterile stub-shoots resemble the sterile appendages of *Psilotum complanatum* (Stiles, 1910). However, the stub-shoots are not necessarily produced in helical order, although occasional distal shoots may show this arrangement (*Fig. 3*).

Synangia typically develop at the tip of certain distal aerial branches. Such branches may be of varying lengths (*Figs. 1–8*). Meiosis has been observed in the synangia, and apparently normal kidney-shaped spores are eventually produced in the locules. The number of locules may be 4 or more rather than the usual 3 (*Figs. 1–3, 8*). As in typical Psilotums, not all aerial shoots bear sporangia, and there is a tendency for sporangium-bearing shoots to occur in groups (*Fig. 4*). Spore production (on a per-aerial shoot basis) may be lower for *sei ryu kaku* than for the typical *Psilotum*

SHOOT APICES, × 1.2. FIG. 11. CLOSEUP OF BASAL PORTION OF SHOOT ABOUT 4 MM FROM SOIL LEVEL AFTER FORMATION OF MULTIPLE APICES, THE UPPER SHOOT SYSTEM BEGINNING TO ELONGATE, × 2.5. FIG. 12. MEIOTIC METAPHASE SHOWING 50 BIVALENTS. SEM PHOTOGRAPHS OF SHOOT APICES: FIG. 13. GROUP OF MULTIPLE SHOOT APICES AT SAME LEVEL AS FIG. 11; FIXED IN FAA; 50% GLYCERINE 24 HRS.; GOLD COATED; NOTE THE EARLY SUBDIVISIONS GENERALLY EQUAL AND SYMMETRICAL, BUT LATER AND INCIPIENT ONES LESS SO, × 14. FIG. 14. GROUP OF SUBDIVIDING SHOOT APICES FROM A SLIGHTLY LATER STAGE THAN FIG. 13, THE AXES BEGINNING TO ELONGATE; NOTE THE APICAL SUBDIVISIONS QUITE UNSYMMETRICAL; FRESH AND UNCOATED, × 23. FIG. 15. GROUP OF ELONGATING SHOOTS AT A SOMEWHAT LATER STAGE OF GROWTH THAN FIG. 13, THESE APICES PERHAPS REPRESENTING THE LAST SUBDIVISIONS PRIOR TO THE COMPLETE AND FINAL ELONGATION OF THE SHOOT; NOTE INITIAL SYMMETRY AND LATER ASYMMETRY; CF. FIG. 5; FIXED IN FAA; 50% GLYCERINE 24 HRS.; GOLD COATED, × 27.5.

where synangia are produced by a series of lateral fertile-appendages along the distal ends of the aerial shoots.

There is evidence of meiotic irregularities. Whether those observed were induced by environmental conditions under which the plants were grown (Okabe, 1929; Barber, 1957), or for other reasons, is not known. In initial chromosome counts of SMC metaphases pretreated with oxyquinoline and stained with aceto-carmine, meiotic bivalents ranged from about 46–56 (e.g. *Fig. 12*). *Sei ryu kaku* is therefore a diploid.

DISCUSSION

The entire scientific literature of *Psilotum nudum* and *P. complanatum* that deals with the origin and relationships of this genus has never considered any type of aerial shoot other than the one that produces reduced leaflike appendages of two intergrading types: (i) a sterile series of awl-shaped appendages on the lower extremities of the shoot, and (ii) a fertile series of forked appendages on the upper extremities of the shoot which is associated with the development of synangia at each appendage (Bierhorst, 1956; Roth, 1963a, b). In *sei ryu kaku*, however, the lower extremities do not have leaflike appendages (*Fig. 10*). When the upper extremities of the shoot are differentiated they are also appendageless (*Fig. 9*), but stub-branches may be produced (*Figs. 2, 3*) by asymmetrical growth. These short stub-branches may resemble the sterile appendages of typical *Psilotum*, but are not produced in a continuous series nor is their number or size consistent. In this variety the synangia are borne only on the tips of branches (*Figs. 1–8*).

The genus *Psilotum* and its companion genus *Tmesipteris* have long been considered modified subtropical and tropical relics of the early land plants of the lower Devonian. This was due in part to the apparent nature of their sporophytes, which seemed to bear little resemblance in growth and structural patterns to those of other primitive plants. Recently, however, Bierhorst (1968a, b, 1969) has taken another look at the problem and has shown a number of structural and developmental similarities

between *Tmesipteris* especially and the enigmatic New Caledonian endemic fern *Stromatopteris moniliformis*. Noting greater similarities between the two genera of the Psilotaceae and *Stromatopteris* than the latter possessed in regard to the family Gleicheniaceae, to which *Stromatopteris* had originally been taxonomically assigned, Bierhorst (1968a) proposed that this apparently anomalous fern be placed in a family of its own, the Stromatopteridaceae. He further stated that the Psilotaceae and the Stromatopteridaceae were too closely related to be separated into separate orders. As a result he transferred *Psilotum* and *Tmesipteris* (Psilotaceae) into the order of ferns (Filicales). As a corollary, the aerial axes of *Tmesipteris* and *Psilotum* would then be considered homologous with the aerial "frond" of *Stromatopteris*. Bierhorst (1969) also postulated that the radially organized aerial axes of *Psilotum*, rather than being primitive, were actually specialized and derived from the winged, leaflike condition of *Tmesipteris*. These sweeping conclusions were based on an impressive amount of morphological and anatomical evidence, much of it gleaned from Bierhorst's own indefatigable collections in the field.

The phytochemistry of the Psilotaceae has been recently enriched by the discovery of a phenolic glycoside, psilotin, that was isolated and identified from *Psilotum nudum* (McInnes, Yoshida & Towers, 1965) and *Tmesipteris tannensis* (Tse & Towers, 1967). According to Tse & Towers the compound has not been identified in representatives of the Lycopodiophyta.

There is a possibility that the phylogeny of the Psilotaceae, long dormant as a subject for scientific inquiry, may well again become a subject of lively controversy.

It may be that, in light of Bierhorst's conception that *Psilotum* has a derived radial shoot or axis, the unusual characteristics of *sei ryu kaku* may or may not have a direct bearing on the determination or confirmation of the phyletic affinities of *Psilotum*. This clone is of more immediate morphogenetic interest because it performs routinely the production of terminal synangia, a phenomenon that occurs only quite rarely, or under environmental stress, in most *Psilotum* genotypes. In typical *Psilotum*, spontaneous

proliferation of the fertile appendage into a short branchlike structure was reported by Sykes (1908) and Bierhorst (1952). Typical *Psilotum* grown under normal or greenhouse conditions have produced synangia in apparently terminal positions (Fabbri, 1963; Abraham & Ninan, 1965; Rouffa, unpublished observations). Also, Bierhorst (personal communication) has noted the existence of a native New Zealand clone in which the synangia are borne at the tips of distinct branches. Such occurrences could certainly strengthen the theory that the forked fertile appendage was evolved from a reduced branch or axial system with terminally produced sporangia. (Bierhorst, 1956; Rouffa, 1967).

Indeed the resemblance of the elongated synangium tipped shoots of *sei ryu kaku* to the aberrant, elongated fertile appendages tipped with synangia produced for at least six years in the author's laboratory on a typical variety of *Psilotum* is rather striking (see Rouffa, 1967, *fig. 4*). The latter aberrant fertile appendages were induced under conditions of low light intensities, red spectrum deficiency, and high temperatures. The effect, although produced quite regularly on an annual basis, appeared unstable since there was a tendency for the same shoot to return to the formation of the normal fertile appendage-synangium structures, even though the inducing environment remained unchanged. To explain this, I postulated that typical *Psilotum* still carries in its genome an ancestral set of genes responsible for the timing sequence of meiosporangium development at the tips of certain branches, but that some form of gene repression (possibly genes acquired through polyploidy) "modernizes" the expression of the branch-sporangium combination to that of a fertile appendage-sporangium combination. I further suggested that, somehow, repressing genes themselves were themselves repressed temporarily at the time of the experiment by the extreme stress of an unusual environment, thereby unmasking temporarily the ancestral condition where sporangia are produced terminally on elongated shoots.

Sei ryu kaku, however, normally produces synangia on the ultimate tips of shoots (both long and short) and does not produce

appendages. According to the above hypothesis, the "modernizing" genes are either continually repressed, or they are not present in the genome in this clone. Future studies on chromosome irregularities in this clone might shed some additional light on these possibilities.

It cannot be denied that this much prized Japanese exhibition *Psilotum* looks for all the world like something out of the Devonian. However, in the face of new evidence, we must exercise caution in assuming that this variety, or any other form of *Psilotum*, is a direct or relic descendent from that period. Nevertheless, there is a distinct possibility that in *sei ryu kaku* some genetic change, as yet unilluminated, has stripped away several hundreds of millions of years of evolutionary modification and there is a remote chance that it represents one of the last of a nearly extinct race of *Psilotum*.

Finally, it may be that we now have been provided the opportunity to learn from its relatively simple structure how the early land plants solved their developmental problems. We are now gathering for this purpose an array of variant genotypes of *Psilotum* which should prove most useful for genetic and morphogenetic analyses and for phytochemical studies.

LITERATURE CITED

ABRAHAM, A. and C. A. NINAN. 1965. Morphological and cytological notes on Psilotum nudum (L.) Beauv. Caryologia: **18**: 537–539.

BARBER, H. N. 1957. Polyploidy in the Psilotales. Proc. Linn. Soc. New South Wales **82**: 201–207.

BIERHORST, D. W. 1952. The morphology, anatomy and the phylogeny of the Psilotaceae. Ph.D. Thesis, University of Minnesota.

———. 1954. The origin of branching in the aerial shoot of Psilotum nudum. Virginia J. Sci. **5**: 72–78.

———. 1956. Observations on the aerial appendages in the Psilotaceae. Phytomorph. **6**: 176–184.

———. 1968a. On the Stromatopteridaceae (Fam. Nov.) and on the Psilotaceae. Phytomorph. **18**: 232–268.

———. 1968b. Observations on Schizaea and Actinostachys spp., including A. oligostachys, sp. nov. Amer. J. Bot. **55**: 87–108.

BIERHORST, D. W. 1969. On Stromatopteris and its ill defined organs. Amer. J. Bot. **56**: 160–174.

CREECH, J. L. 1957. Plant explorations. Ornamentals in southern Japan. U. S. Department of Agriculture, Agr. Res. Serv. **34–1**: 1–55.

FABBRI, F. 1963. Terminal sporangia at the apices of branches in two plants of Psilotum nudum (L.) Beauv. A preliminary report. Giorn. Bot. Ital. **70**: 591–595.

MCINNES, A. G., S. YOSHIDA, and G. H. N. TOWERS. 1965. A phenolic gycoside from Psilotum nudum (L.) Griseb. Tetrahedron **21**: 2939–2946.

NINAN, C. A. 1956. Cytology of Psilotum nudum (L.) Beauv. (P. triquetrum Sw.). La Cellule: **57**: 307–318.

OKABE, S. 1929. Uber eine tetraploide Gartenrasse von Psilotum nudum, Palisot de Beauvois (= P. triquetrum, Sw.) und die tripolige Kernteilung in ihren Sporenmutterzellen. Science Reports, Tohôku Imperial University, IV, **4**: 373–379.

ROUFFA, A. S. 1967. Induced Psilotum fertile-appendage aberrations. Morphogenetic and evolutionary implications. Can. J. Bot. **45**: 855–861.

———. 1968. An appendageless form of Psilotum. Amer. J. Bot. **55**: 714. (Abstr.)

ROTH, I. 1963a. Histogenese der Luftsprosse und Bildung der "dichotomen" Verzweigungen von Psilotum nudum. Adv. Front. Pl. Sci. **7**: 157–179.

———. 1963b. Histogenese und morphologische Deutung der Blätter von Psilotum nudum. Flora (Allgem. Bot. Zeit.) **153**: 90–111.

STILES W. 1910. The structure of the aerial shoots of Psilotum flaccidum, Wall. Ann. Bot. **24 (O.S.)**: 373–387.

SYKES, W. G. 1908. A note on an abnormality found in Psilotum triquetrum. Ann. Bot. **22 (O.S.)**: 525–526.

TSE, AIDA and G. H. N. TOWERS. 1967. The occurrence of psilotin in Tmesipteris. Phytochemistry **6**: 149.

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Vascularization of Fern Leaves

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The subject of fern leaf venation is a very old topic and it has been dealt with by many authors during the nineteenth and twentieth centuries. Most of the discussions of fern leaf venation concentrate on its qualitative aspects resulting in descriptions of various types of leaf venation. Considerably less attention has been devoted to the quantitative aspects of fern leaf vascularization. This report will give a brief summary of some of the measurable aspects of the vascular system within the leaves of certain rather common ferns.

The collections of the ferns used in this study came from two sources. Those collected out-of-doors came from Giant City State Park or from Jackson Hollow, six miles northeast of Simpson, Illinois. Material was taken with the permission and under the supervision of Dr. Robert H. Mohlenbrock of Southern Illinois University. Other ferns were obtained from the Department of Botany greenhouse at the University of Nebraska.

The fern leaves were studied from slides made of cross sections of the material which had been stained with Delafield's hematoxylin and safranin. Whole mounts of cleared leaves or leaflets or parts of these were also studied to obtain vein patterns and angle of branching.

All measurements recorded in this study were made by means of an ocular micrometer. All those listed in *Table I* are averages of many separate measurements. Leaf thickness was measured at veins rather than between veins. Intervascular interval was measured from the vascular tissue of one bundle to the vascular tissue of the next adjacent bundle; thus it includes any specialized parenchyma or bundle sheath cells. Vein width includes only the width of the conductive tissues of a vascular bundle. Angle of branching refers to the branching of vascular bundles from the midvein of the leaf or segment and not to the ultimate branchings in the lamina. It was measured in linear units and the angle

computed as a trigonometric function. Dissection of leaves as used in this study was an arbitrary rating scale which divided

TABLE I. SUMMARY OF LEAF MEASUREMENTS OF SOME COMMON FERNS

Species	*Source*	*LT in μ*	*IVI in μ*	*VW in μ*	*AB in degrees*	*D*
Botrychium virginianum	I	260	747	85	39	5
Osmunda cinnamomea	I	125	426	32	41	3
Trichomanes boschianum	I	98	799	45	51	1
Pteris vittata	G	108	463	53	43	2
Pteris cretica	G	174	791	79	39	2
Cheilanthes lanosa	I	135	281	28	43	4
Pellaea atropurpurea	G	195	396	45	41	4
Adiantum pedatum	G	56	622	38	48	5
Adiantum capillus-veneris	G	72	323	20	32	5
Nephrolepis exaltata	G	176	561	45	38	2
Woodsia obtusa	I	177	429	39	37	3
Polystichum acrostichoides	I	286	496	44	53	2
Cyrtomium falcatum	G	336	744	78	42	2
Dryopteris dentata	G	108	404	43	42	3
Dryopteris marginalis	I	171	607	42	42	4
Dryopteris spinulosa	I	110	633	38	40	5
Dryopteris hexagonoptera	I	99	581	18	45	3
Athyrium filix-femina	I	138	437	30	33	4
Asplenium trichomanes	I	90	429	30	34	2
Asplenium platyneuron	I	140	500	38	35	2
Camptosorus rhizophyllus	I	219	984	57	62	0
Polypodium vulgare	G	176	736	78	43	1
Polypodium virginianum	I	200	681	42	44	1
Phlebodium aureum	G	114	1214	69	44	1

I = Southern Illinois; G = Greenhouse, Univ. of Nebr.; LT = leaf thickness; IVI = Intervascular interval; VW = vein width; AB = angle of branching; D = Dissection of leaf: 0 = entire; 1 = pinnatifid; 2 = pinnate; 3 = pinnate-pinnatifid; 4 = twice-pinnate; 5 = more than twice-pinnate.

fern leaves into six groups. These were designated by a numerical scale from 0, which represented entire leaves, to 5, which included those which were more than twice pinnate.

LEAF THICKNESS

In general, the leaf thickness at vascular bundles is greater than it is between them. In five species the leaf thickness at the vascular bundle exceeded the sum of leaf thickness between veins and the vein width. This indicates an actual build-up of tissue around the vein. These five species are *Osmunda cinnamomea*, *Trichomanes boschianum*, *Woodsia obtusa*, *Dryopteris hexagonoptera*, and *Asplenium platyneuron*. The leaf blade is thicker between veins than it is at the veins in three species, namely *Pteris vittata*, *Adiantum capillus-veneris*, and *Dryopteris marginalis*. The measurements listed for LT in *Table I* are averages of those taken at the vascular bundles.

There appears to be no great modification of leaf thickness due to environment as judged from leaves collected from the two sources. The averages of leaf thickness for these fern leaves was from 56 microns in *Adiantum pedatum* to 336 microns in *Cyrtomium falcatum*.

INTERVASCULAR INTERVAL

Measurements of IVI were taken where the adjacent vascular bundles were nearly parallel. The predominantly dichotomous branching of lateral vascular bundles sometimes occurs near the midvein as in *Osmunda cinnamomea*, *Dryopteris hexagonoptera*, and *Nephrolepis exaltata*. In *Pteris vittata* some lateral vascular bundles branch near the midvein and adjacent ones branch midway to the margin or very near the margin. Other ferns, such as *Adiantum pedatum* and *Asplenium platyneuron*, show several branchings of one vascular bundle.

Ferns with the largest leaf segments have correspondingly large intervascular intervals. *Table I* shows that for *Phlebodium aureum*, *Camptosorus rhizophyllus*, *Pteris cretica*, and *Cyrtomium falcatum* the IVI is over 700 microns. Other ferns having intervascular intervals in this range, however, include plants with smaller leaf segments, such as *Botrychium virginianum*, *Trichomanes boschianum*, and *Polypodium vulgare*.

Comparisons of IVI with the dissection of leaf (D) listed in the right hand column of *Table I* have been illustrated in *Fig. 1*. Except for group 5, the IVI measurements for each group decrease as the dissection of the leaf increases. In *Fig. 1* the wide variations within each group are not related to the source. For example, the greatest IVI in group 1, *Phlebodium aureum*, and the smallest IVI in group 5, *Adiantum capillus-veneris*, were both grown in the greenhouse. It might be profitable to study the combination of segment size and leaf dissection as it may be related to intervascular interval.

VEIN WIDTH

Vein width measurements show no constancy or correlation with source of material, genus, leaflet size, or leaf dissection. The range of vein width from 18 to 85 microns indicates that the tissue requirements of each species govern the size of veins.

ANGLE OF VEIN BRANCHING

In the genera *Dryopteris* and *Polypodium* the species studied show similar angles of branching of the veins. In *Woodsia* and *Adiantum* the two species of each genus which were examined have considerably different angles of branching. *Woodsia obtusa* shows 37° and *Woodsia scopulina* 30° (not shown in the table). The Adiantums are also very different, with angles of 32° and 48°.

Since the angle of branching is measured from the midvein of the segment, the degree of dissection probably affects the angle at which lateral veins arise. The midveins in a highly dissected leaf are farther removed from the rachis. A correlation of the degree of dissection and the angle of branching, however, failed to show any significance for the species studied. A more detailed and refined treatment of these characteristics might be profitable.

DISCUSSION

The tissues of the fern leaf do not show some of the specializations commonly seen in the leaves of higher plants. The epidermis is not as highly specialized unless the inner lobes filled with chloroplasts are considered to be a specialization. The mesophyll of

many ferns is not noticeably differentiated into palisade and spongy layers as are many dicotyledonous leaves. This condition emphasizes the horizontal continuity of the leaf tissues. The build-up of tissues around the veins of many ferns also allows for the greater distributive and collective area for the vascular bundle, as emphasized by Armacost (1944).

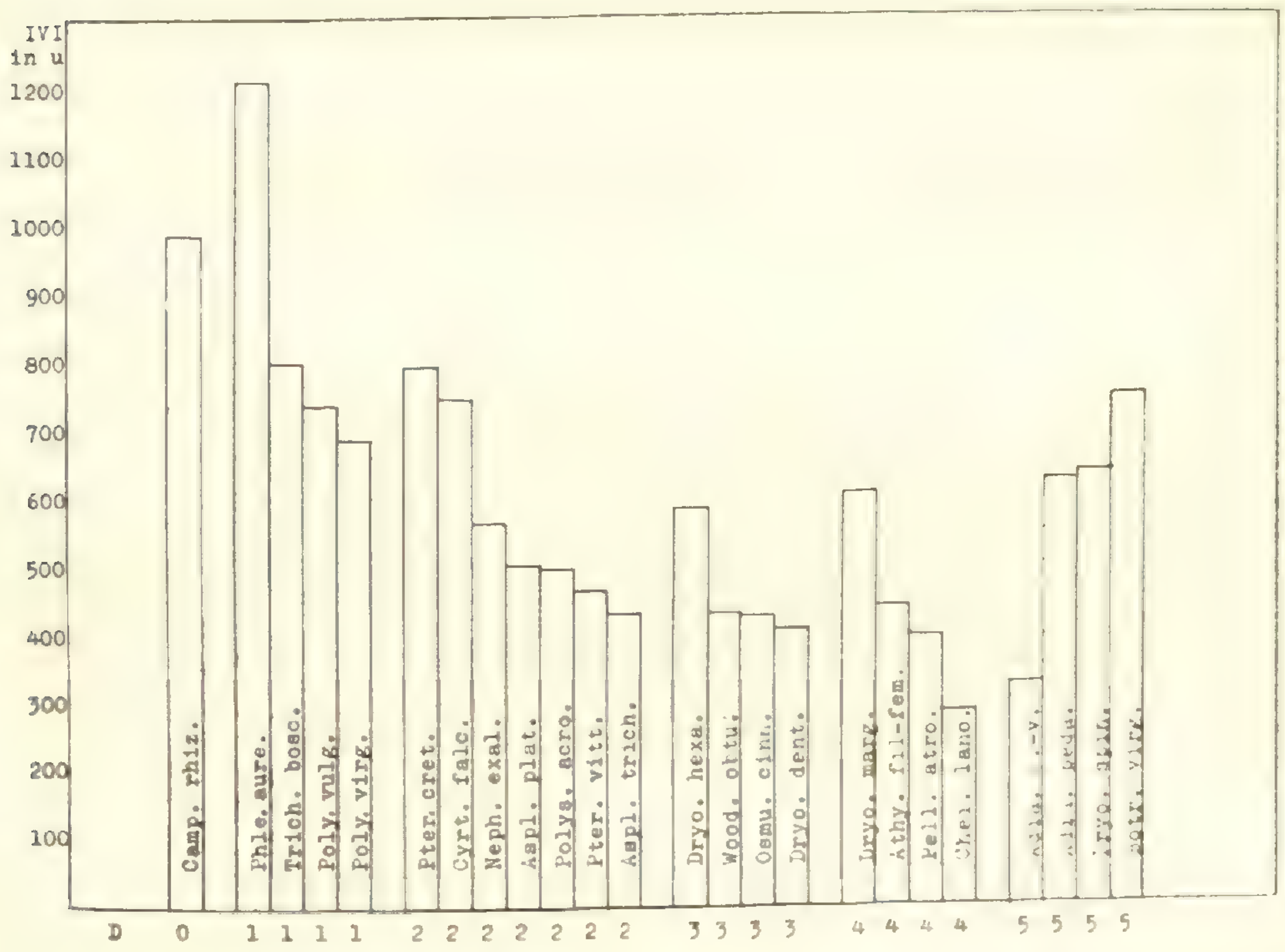

FIG. 1. A HISTOGRAM OF CERTAIN COMMON FERNS ARRANGED IN GROUPS BASED ON THE DEGREE OF DISSECTION ILLUSTRATING THEIR RESPECTIVE INTERVASCULAR INTERVALS MEASURED IN MICRONS.

Although the average leaf thickness in this study of fern leaves is 149 microns, about one half of the species have a thickness between 60 and 140 microns. This is strikingly similar to the findings of Wylie (1946) in his study of ninety species of Florida dicotyledons in which 53 species had an average thickness within this range, but the average thickness of all 90 species was 56

microns—more than for these ferns. When compared with his study (Wylie, 1939) of 22 Iowa woody plants and 24 Iowa herbaceous plants, which had leaves averaging 152 and 163 microns respectively, these ferns are not significantly thinner. The factor which gives the impression of thinness in fern leaves is the absence of the abundant network of major veins that gives structural rigidity to many dicotyledonous leaves.

The vein width has already been referred to in estimating the build-up of tissues around the vein. Although the veins in ferns are somewhat smaller at their tips and larger at the base of leaflets, many ferns fail to show, aside from a large midrib, the degree of difference referred to in other types of leaves as primary, secondary, tertiary and so forth. This can be explained by one of the principles of Bower (1923) which says that in most fern leaves there persists a distal dichotomy in the venation. The vein width does not correlate with the IVI, the angle of branching, or the degree of dissection of the leaves. It does correlate weakly with leaf thickness. Bower (1923) also suggested that in evolution the factors of leaf venation and leaf dissection do not advance together.

If the method of Ettingshausen (1861) in measuring the angle of branching had been used, more consistent results might have been obtained and the angles would have been larger.

Wylie (1939) mathematically defined the relationship between tissue organization and vein distribution in dicotyledonous leaves. He showed that with large ratios of spongy to palisade mesophyll the intervascular interval was large, and conversely, when there was a relatively thick palisade layer the intervascular interval was correspondingly small. Later Wylie (1948) pointed out the dominant role of the epidermis in two species of *Adiantum*. The lobed epidermal cells of ferns can be considered spongy mesophyll since they are parts of a horizontally contiguous tissue. In some ferns there is little or no mesophyll which may be considered to be vertically oriented palisade mesophyll. We should not be surprised, therefore, to find such large intervascular intervals in the ferns as compared with angiosperm leaves. In this study the average of all IVI measurements was 595 microns. For 194 species

of dicotyledons from Iowa, Florida, the Pacific coast, and New Zealand, Wylie (1939, 1946, 1954) found an average IVI of 143 microns. Philpott (1953) in a study of 47 species of *Ficus* found an average IVI of 155 microns. Lommasson (1948) in a study of 37 species of grasses found an average IVI of 141 microns. Since the IVI represents the distribution of the smallest veins of the leaf and since they are among the last tissues of the leaf to develop, they represent the final adjustment of the vascular tissue to the environmental conditions in which the plant is growing. These results again point to the often suggested idea that vein spacing is dependent upon the tissue organization of the leaf and that this in turn is governed by the demands of the constituent chlorophyll bearing cells.

LITERATURE CITED

ARMACOST, R. R. 1944. The structure and functions of the border parenchyma and vein-rib of certain dicotyledon leaves. Proc. Iowa Acad. Sci. **51**: 157–169.

BOWER, F. O. 1923. The Ferns. Vol. 1. Cambridge.

ETTINGSHAUSEN, C. R. VON. 1861. Die Blatt-Skelete der Dikotyledonen. Wien.

LOMMASSON, R. C. 1948. Tissue relations of grass leaves. University of Iowa, Dissertation.

PHILPOTT, JANE, 1953. A blade tissue study of leaves of forty-seven species of Ficus. Bot. Gaz. **115**: 15–35.

WYLIE, R. B. 1939. Relations between tissue organization and vein distribution in dicotyledon leaves. Amer. J. Bot. **26**: 219–225.

———. 1946. Relations between tissue organization and vascularization in leaves of certain tropical and subtropical dicotyledons. Amer. J. Bot. **33**: 721–726.

———. 1948. The dominant role of the epidermis in leaves of Adiantum. Amer. J. Bot. **35**: 465–473.

———. 1954. Leaf organization of some woody dicotyledons from New Zealand. Amer. J. Bot. **41**: 186–191.

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Shorter Note

A WRONGLY LOCALIZED SPECIES OF PYRROSIA.—*Niphobolus cuneatus* Kuhn (Bot. Zeit. **26**:40. 1868) was described from material distributed by Hohenacker "in territorio rei publ. Ecuador" no. 5. Since *Niphobolus* was considered a synonym of *Cyclophorus* by Christensen, the new combination *Cyclophorus cuneatus* (Kuhn) C. Chr. (Ind. Fil. 198. 1905) was published, but apparently no pteridologist has ever looked carefully at the type since the original publication of the species.

Both *Niphobolus* and *Cyclophorus* are later names for the genus now known as *Pyrrosia*. In the "Index Filicum," there were only two American species recognized, both of them a query—*C. americanus* (Hook.) C. Chr. and *C. cuneatus*. The former was properly considered a different genus, *Niphidium*, by John Smith. And thus *C. cuneatus* remains as nominally the only American species of this genus.

Through the courtesy of Dr. Eckhardt and Dr. Meyer, the type of *N. cuneatus* has been made available to me on loan. It is a minute specimen, containing about a half dozen fronds and a short length of rhizome. The material is sterile only. However, even in the absence of fertile fronds, it is readily identifiable as *Pyrrosia rupestris* (R. Brown) Ching, a species confined to Australia. The minute, obovate sterile blades, densely covered beneath with stellate scales, these with a conspicuous, minute, round, red central disk and elongate straight white rays are characteristic; the rhizome scales agree also, these being elongate-lanceolate, light brown, and not ciliate.

It is not at all likely that this Australian species occurs in Ecuador, and so a wrong label may be presumed. Hohenacker distributed plants from many parts of the world and a confusion of data is not at all improbable. The genus *Pyrrosia* is therefore to be excluded from the flora of the New World.—C. V. MORTON, *National Museum of Natural History, Washington, D.C. 20560.*

Recent Fern Literature

THE GENUS ADIANTUM IN CULTIVATION [POLYPODIACEAE], by Barbara Joe Hoshizaki. Baileya **17**, nos. 3–4, pp. 97—191. *f. 1—45.* 1971. Published by the L. H. Bailey Hortorium, Cornell University, Ithaca, N. Y., $1.50.—In continuing her studies of cultivated ferns, Barbara Joe has given us a useful treatment of the maidenhair ferns, which are popular with florists. These beautiful ferns are delicate, and do not like the hot dry atmosphere of most houses and apartments. Consequently, they are best grown in greenhouses, where most of them are of relatively easy culture. Twenty species are recognized as being in cultivation in the United States, but almost all the named cultivars belong to *Adiantum raddianum* (usually called *A. cuneatum*), the "Delta Maidenhair." The text is made most usable by the good line drawings of typical pinnules and by silhouettes of the blades. Many of the named forms are not easily determinable, because they vary greatly according to cultural conditions and also intergrade with each other extensively. It is indicated that some of the cultivars can arise repeatedly *de novo* from normal parents. This is evidently a genus that would repay genetical study.[1]—C.V.M.

POLLEN AND SPORES OF CHILE, by Calvin J. Heusser. Pp. 1—95, *pl. 1—60.* 1971. Published by the University of Arizona Press, P. O. Box 3398, College Station, Tucson, Arizona 85700, $15.00. The present work describes, keys, and illustrates by photomicrographs 54 species of Pteridophyta of Chile, the Juan Fernandez Islands, and Easter Island [which is rather remote from Chile in its flora and more closely related floristically to Polynesia]. The work appears to be carefully done, using the Erdtman method of spore preparation. However, it may be doubted that this approach is truly valid at present. The scanning electron microscope is revolutionizing the study of spores, for it shows up many details

[1] Mrs. Hoshizaki has asked me to point out two typographical errors: On p. 104, "2–3 pinnate" is transposed with "3–4 pinnate"; on p. 132 "Aa" is a pinna, not a frond.

that can not be seen at all with the ordinary microscope, even with great magnification. The present photographs are hardly good enough for a clear identification of the species. The only out-and-out error that I notice is the inclusion of the description and illustration of the spores of "*Davallia valdiviana,*" although there is no such published species. Since the specimen concerned is deposited in the museum in Santiago it could have been properly identified. The genus *Davallia* does not grow in Chile, and so I would guess, without evidence, that the plant concerned is *Rumohra adiantiformis;* this species is related to *Davallia,* and although common in the Province of Valdivia is not otherwise included in this treatment. Since most of the text and illustrations in this work concern the phanerogams, the book will be of more use to students of the flowering plants.—C.V.M.

FLORA DE VENEZUELA, VOL. I. HELECHOS, by Volkmar Vareschi. Instituto Botánico, Aptdo. 2156, Caracas, Venezuela. 1033 pp. 1968.—This volume, which is bound in two portions, illustrates well the difficulties of preparing detailed floras in tropical areas. Although about 700 species are treated, in some groups (e.g., *Polypodium* and the Cyatheaceae) the list of "critical species," those that are published but which were not studied by the author, contains 60–80% as many as those accounted for in the flora! The volume is dated 1968 on the title page and 1969 on the soft-bound cover, but dates in the text indicate that the writing was completed as early as 1960. Critical recent literature is often not cited nor additions and corrections apparently made. Most surprising is the seriously flawed nomenclature. About 200 names are invalid for one or more reasons, including the lack of a Latin description, a basionym, or a type specimen. There are, however, 44 valid nomenclatural changes, 31 intentional and 13 unintentional. Of the former, 2 are illegitimate and 29 are legitimate: of the latter, 6 are illegitimate and 7 are legitimate. Reference is made to specialized details of anatomy, morphology, and paleobotany, which is useful and missing from most floras. The illustrations are well executed and helpful.—D.B.L.

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American Fern Journal

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The Fern Vegetation of Aldabra Atoll

F. R. Fosberg[1]

Aldabra is a ring-shaped coral island in the western Indian Ocean, 260 miles northwest of the northern tip of Madagascar and 400 miles east of Africa. Unlike the majority of coral atolls it has been elevated by tectonic forces about 5–6 m. The island is noted, for more than any other reason, as the last stronghold in the Old World of the giant tortoises that formerly roamed many regions of the earth. They now survive only in the Galápagos, where they are rare, and on Aldabra, where they are still abundant.

The climate of Aldabra is dry and hot, and scarcely favors the development of much of a fern flora. Although ferns are prominent in several habitats, the fern flora is exceedingly poor. One species had been recorded prior to the Royal Society Expedition (1966–1967) and, despite some weeks of active collecting by two botanists and several other scientists interested in the vegetation, the known fern flora still remained a single species, *Acrostichum aureum* L., until a tiny colony of *Nephrolepis biserrata* (Swartz) Schott was found by Mr. S. A. Renvoise in a depression in a barren area of windbeaten rough limestone near the southeast coast. No further colonies, nor any other species, have been found on the atoll.

That prominent and varied fern vegetation may be made up of essentially a single species is very odd, indeed. *Acrostichum* is a

---

[1] The observations reported here were made while the author was a member of the Royal Society Aldabra Expedition, in January and February, 1968. Thanks are due to the Royal Society and to the Smithsonian Institution's Office of International Activities for the privilege of participating in this enterprise.

Volume 61, No. 2 of the Journal, pp. 49–96, was issued June 24, 1971.

Fig. 1. Coral "champignon" with Acrostichum and tortoise. Fig. 2. Small Acrostichum aureum plants in coral pits near the beach. Photos by Jay Shaffer.

big, coarse, leathery fern with erect fronds. It is usually associated with mangrove swamps and coastal marsh vegetation throughout most of the Tropics. On Aldabra there are notable mangrove swamps, but *Acrostichum* was not seen in any of them. To visualize where it does occur a brief account of the main surface features of the island is necessary.

The island is a flat, almost complete ring of reef limestone, little higher than 7 m except for dunes, broken by several channels through which the tides race twice a day in and out of the great, shallow lagoon. The land area is about 60 square miles and, although entirely of limestone, exhibits several different types of surface. Much of it is extremely eroded into sharp pinnacles, ragged projections, deep pits, fissures, chimneys and crevasses. The edges are razor-sharp where the relief is too high for the tortoises to climb over it (*Fig. 1*, background), but where the relief is more moderate, the rubbing of their great shells has rounded off the projections (*Fig. 1*, foreground). This rough type of surface is locally called "champignon"; in Polynesia it is called "feo." In the interior of some of the islands are areas of a flat, smooth or often slab-covered surface, called "platin," with solution basins, fat soil areas, deep cracks and fissures, and numerous pools of water and mud. The pools have either sloping or vertical sides, and the water varies from fresh to as saline as sea-water or even more so. Storm beaches and occasional dunes of coral sand line some of the coasts, as on the northeast, east, and parts of the south sides of South Island, which is by far the largest of the four main sections of the ring of land.

It is not surprising to find that luxuriant masses of *Acrostichum* entirely or partly fill many of the pools, especially and almost exclusively those with vertical sides and mud bottoms. It tolerates a remarkable range of salinities, by actual tests ranging from 1,700 to 15,700 parts per million dissolved salts. In these pools the masses of thick, creeping, branched rhizomes are dense, and the erect fronds are crowded in compact clumps which reach 1.5 or even 2 m in height from the mud. The larger pools could appropriately be called marshes.

One sizeable area which I visited has a number of such pools, filled with *Acrostichum*, but in addition, several hectares of "platin" surface are intricately cracked. The cracks are filled with *Acrostichum*. The rhizomes are mostly in the tops of the deep but narrow cracks; the abundant roots go down to the water as much as one meter below. The fronds here are smaller than in the pools, usually somewhat over 0.5 m tall, and the area has the appearance of an *Acrostichum* "meadow". Scattered bushes of *Ficus avi-avi* L. make parts of this area look like a miniature fern "savanna."

Even more remarkable was an extensive area 100–300 meters wide of "champignon" extending along the east coast of the island back of the line of dunes (*Fig. 1*). In most of the island the "champignon" is covered by thick scrub, but here, possibly because of exposure most of the year to salt-spray blown by the tradewinds, there is little woody vegetation. Instead, in addition to a few herbs and dwarf shrubs hiding in fissures, pits, and chimneys, *Acrostichum* is the principal component of the vegetation (*Fig. 2*). Deep pits, a few centimeters in diameter, occur in great numbers in this limestone. Many of these have each an erect tuft of dwarfed *Acrostichum* fronds rising from a bit of rhizome down in the bottom of the pit. The fronds are from a few cm to 0.5 m tall, and even taller where they grow in chimneys or crevasses that afford better shelter. Occasional tiny plants grow in deep crevices. The whole area is very sparsely covered by these tufts of erect, green, leathery fronds. Many of the fronds have several terminal pinnae densely covered on the dorsal side by sporangia, seen under a lens to be arranged in a close network. Pits in rough limestone in almost any part of the island are likely to be occupied by *Acrostichum*, but along the east coast it is the principal vegetation on large areas.

That one species of fern is able to assume such variations in habit and to tolerate such a range of conditions that it can fill a series of niches normally occupied by other species shows the capabilities that may be brought out by a wide variety of habitats and little competition from other species. An interesting question is why *Acrostichum* is not found in Aldabra's mangrove swamps, which usually are regarded as its normal habitat. Perhaps there

is merit in the suggestion that the mangrove fern is actually a species of *Acrostichum* other than *A. aureum* L. Watson (Malayan For. Recs. **6:** 152–157. 1928) has distinguished *A. speciosum* Willd. as a species tolerating more frequent tidal inundation. No plants corresponding to the description of this, which has conspicuously acuminate pinna tips, have been found in Aldabra.

DEPARTMENT OF BOTANY, U. S. NATIONAL MUSEUM, WASHINGTON, D. C. 20560.

Leaf Epidermal Studies in Marsilea

JOHN T. MICKEL AND FRANK V. VOTAVA[1]

The aquatic fern genus *Marsilea* is widespread and well known throughout the world. Of the nearly 70 extant species, 20 are found in the New World. Many studies have been made on the genus from the standpoints of its physiology, morphology, anatomy, and development. Frequently there are difficulties in species identification since the taxonomic characters lie primarily in the reproductive structures—the sporocarps—and herbarium specimens are often sterile. A search was begun for vegetative characters to distinguish the species of North America, Mexico, and the West Indies. As part of this study leaf clearings were made, and some notable diversity was found within the group.

Gupta (1957), in a preliminary study of the epidermal and soral characters of some American species of *Marsilea*, reported that the epidermis could be of some taxonomic value. Species differ, he said, in the walls of the epidermal cells ("smooth, slightly wavy, and highly wavy") and in the frequency of the stomata. He illustrated the epidermal patterns of 11 species and counted and

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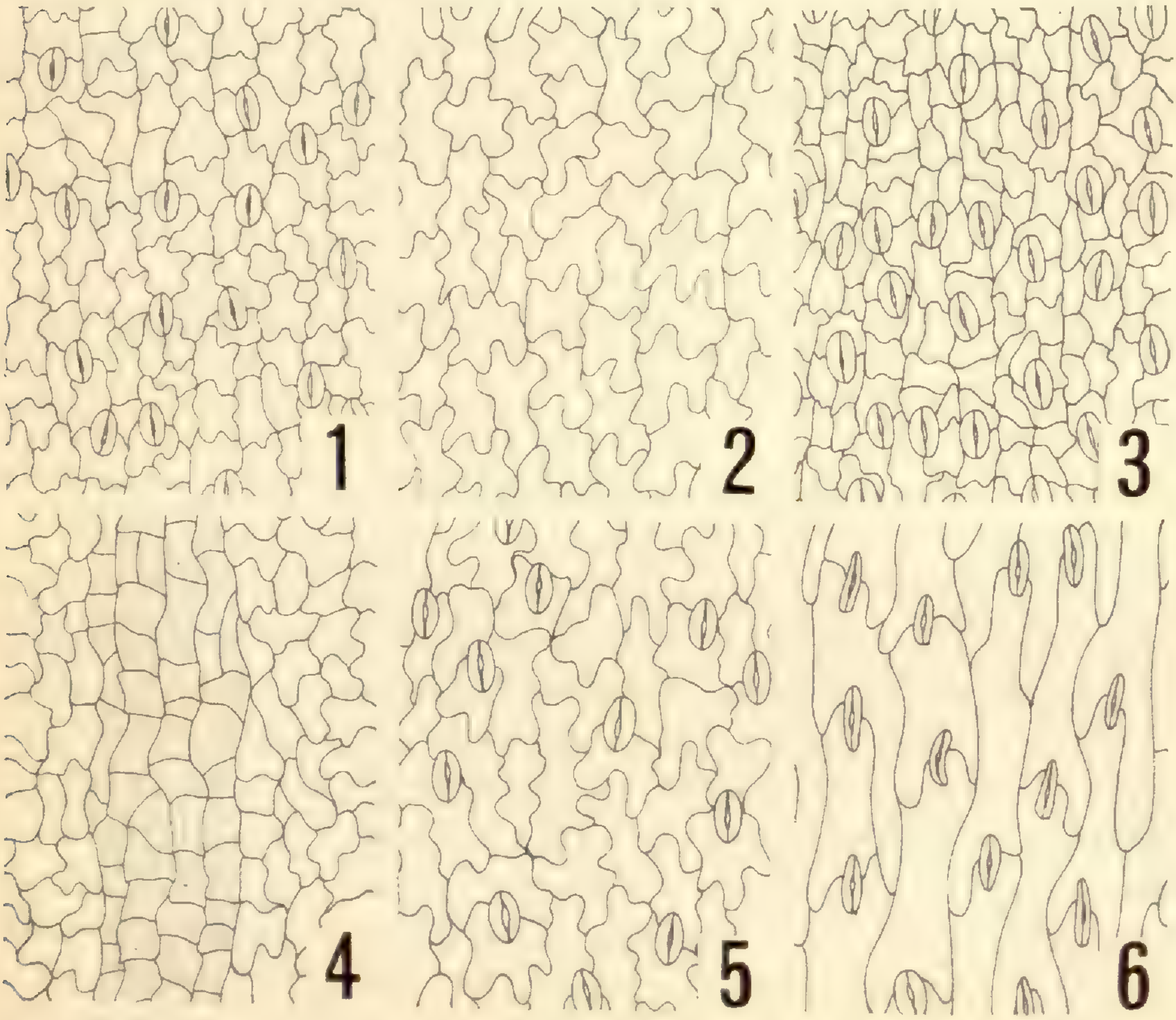
measured the stomata. His monograph of the Indian species (1962) reported differences in epidermal patterns under different ecological conditions.



MARSILEA EPIDERMIS. FIG. 1. M. QUADRIFOLIA, UPPER. FIG. 2. SAME, LOWER. FIG. 3. M. MEXICANA, UPPER. FIG. 4. SAME, LOWER. FIG. 5. M. POLYCARPA, UPPER. FIG. 6. M. NASHII, UPPER.

Our clearings of 13 species were studied in regard to stomatal size, frequency and position, epidermal patterns, and certain ecological effects. Our findings differ somewhat from and go beyond those of Gupta sufficiently to merit reporting them here.

Clearings were made of all 13 species found in North America, Mexico, and the West Indies. The specimens are cited in *Table I*, and all are in the herbarium of The New York Botanical Garden. Leaflets were cleared in 5% KOH for 1–2 days and were then

bleached in 20% Chlorox solution. The clearings were stained with tannic acid and ferric chloride and mounted in diaphane.

EPIDERMAL PATTERNS

We found roughly the same variation in epidermal patterns that Gupta reported: (i) those with long cells and smooth walls (*Figs. 6, 7*), and (ii) those with wavy walls that range from only slightly wavy to strongly undulating (*Figs. 8–15*); but we could distinguish another group, those with short, blocky cells (*Figs. 1–5*).

Smooth walls are quite distinctive and are found in *M. nashii* and *M. tenuifolia*. This character may be related to their very slender pinnae.

Short, blocky epidermal cells were found consistently in our specimens of *M. quadrifolia*, *M. polycarpa*, and *M. mexicana*. Their walls vary in wall waviness, even within a species. In *M. polycarpa* the cells tend to be more elongate than in the other two species.

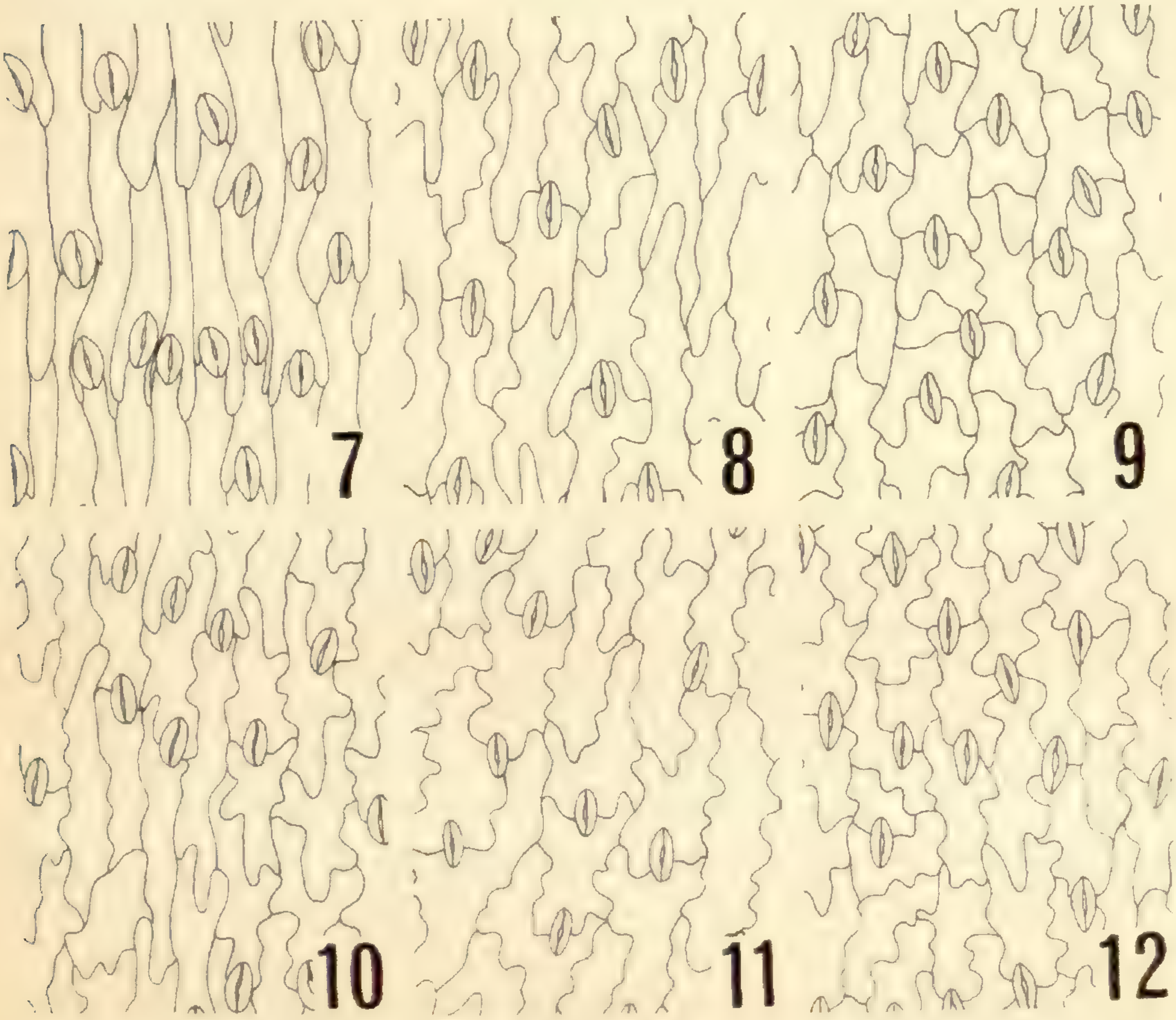
Most species have somewhat elongated cells with variously undulating walls (*Figs. 8–15*). There seems to be considerable variation, and we found it impossible to separate sharply those with slightly wavy walls from those with deeper undulations, as Gupta (1957) attempted to do. *Marsilea mucronata*, *M. vestita*, and *M. oligospora* are generally considered closely related and have been combined by some authors (Hitchcock et al., 1969; Reed, 1954). Their combined range covers the western half of the United States. Gupta (1957) reported the latter two species to be distinct in epidermal pattern and stomatal frequency; however, we found all three to be essentially the same in these characters.

In all species the cells toward the base of the pinnae have smoother walls than do the more distal ones; the former grade into the square or rectangular cells of the rachis epidermis.

EPIDERMAL STREAKS

We examined only aerial leaves and floating leaves, so we did not find the ecological differences in epidermal wall patterns of aerial versus submerged leaves reported by Gupta (1962) and Gaudet (1964a). The latter are said to have smoother cell

walls than the aerial leaves. We found essentially no differences in epidermal cell walls between floating and aerial leaves. Van Cotthem's drawings of *M. quadrifolia* (1970, *fig. 535*) show more elongate cells with more deeply wavy walls than in our specimens.



MARSILEA UPPER EPIDERMIS. FIG. 7. M. TENUIFOLIA. FIG. 8. M. FOURNIERI. FIG. 9. M. UNCINATA. FIG. 10. M. MACROPODA. FIG. 11. M. MOLLIS. FIG. 12. M. BERTEROI.

The presence of stomata on both surfaces of his specimen suggests it was not floating and that perhaps in this case floating and aerial leaves display somewhat different epidermal patterns.

One morphological feature which appears to be correlated with floating leaves is the presence of reddish streaks on the under surface of the leaflets. The presence of these streaks has been

used occasionally as a key character in determining *M. mexicana* (Knobloch and Correll, 1962, p. 47). The streaks are also commonly found in *M. quadrifolia* and *M. polycarpa*. They are not merely chance streaks of pigmentation, but have an anatomical basis. In these areas the epidermal cells have thinner, smoother walls than do the surrounding epidermal cells (*Fig. 4*). The presence of the streaks is strictly correlated with the absence of stomata on the lower surface, suggesting that these are floating leaves. Leaves with stomata on the lower surface have no streaks; an intermediate condition was seen in a single specimen of *M. quadrifolia, Maldenke 4608*, which has a very low number of stomata and suggestions of streaks of thin-walled cells on the lower surface that can be seen under the microscope.

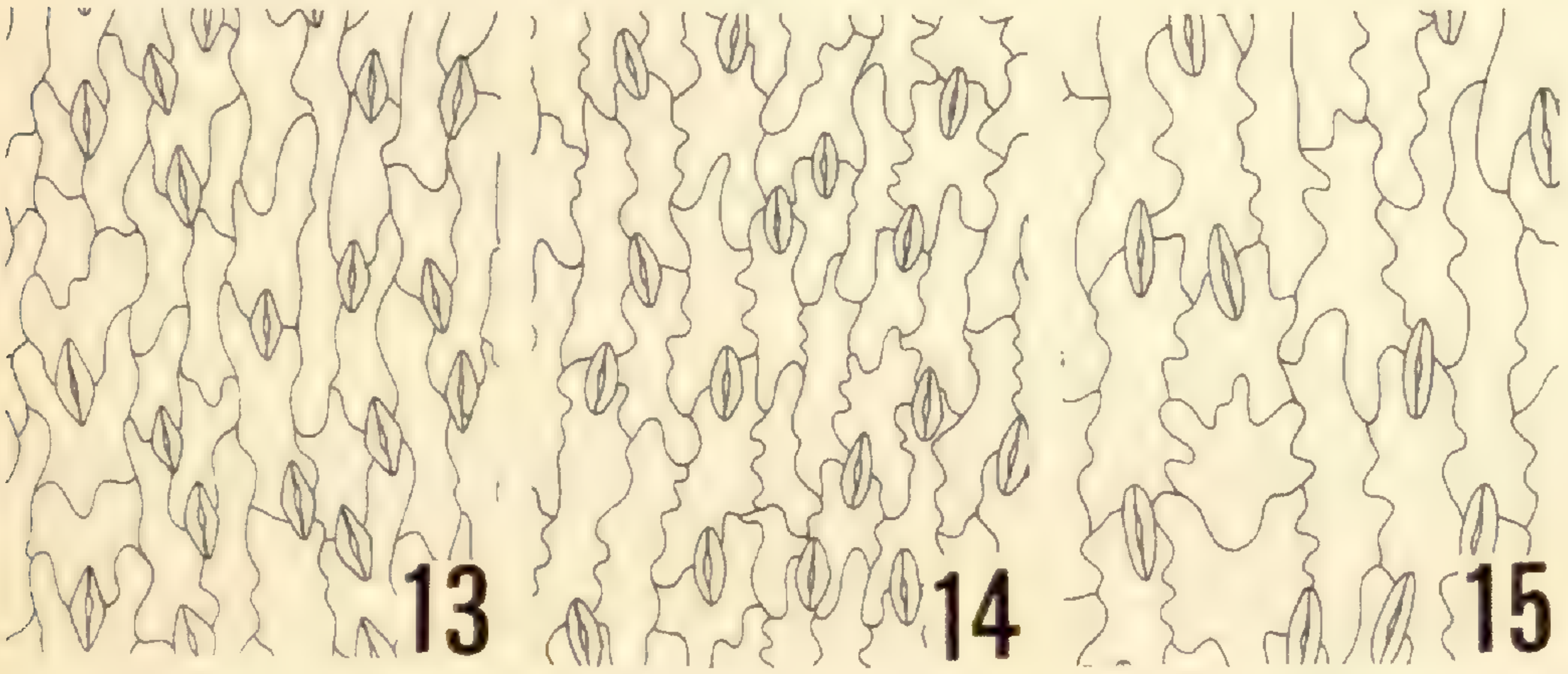
The streaks are by no means constant for any of the species mentioned above, but they are much more common in these than in any others. They have been seen in four specimens of the *M. oligospora-vestita-mucronata* complex from the western United States and in *M. deflexa* from South America. This feature frequently occurs in species commonly found in water, which naturally have floating leaves frequently. The other species generally live in intermittent pools or moist meadows that are inundated only infrequently, and so only rarely have floating leaves.

The fact that the cells have thin, smooth walls suggests that because of their submerged condition these areas are slow to differentiate and essentially remain in a juvenile condition. Whether these areas have a function is not known.

STOMATAL FREQUENCY

Stomatal size and relative frequency were determined for the upper and lower surfaces of all species. Frequency was measured in five samples from each surface by counting the stomata visible in an ocular reticle (area 0.0715 mm^2). The averages are given in *Table I*. As noted above, some plants have no stomata at all on the lower surface. It would appear from this feature, from the appearance of the plants (long petioles, few or no hairs), and rarely from label data, that these leaves were floating on the

water. Gaudet (1964b) found floating leaves of plants grown in culture to have no stomata on the lower epidermis. This is to be expected since the floating leaves of water lilies (*Nymphaea*) have stomata limited to the upper surface, and the submerged leaves of members of the Podostemaceae have no stomata on either surface. It is interesting to note, however, that totally submerged leaves of *Marsilea* will initiate stomata on the upper but not the lower surface (Gaudet, 1964a).



MARSILEA UPPER EPIDERMIS. FIG. 13. M. MUCRONATA. FIG. 14. M. OLIGOSPORA. FIG. 15. M. VESTITA.

In spite of the location of the stomata on the upper surface and the frequent lack of stomata on the lower surface, the internal anatomy of the leaves is of the traditional configuration, with a palisade layer under the upper epidermis and an open spongy mesophyll layer below. There are air spaces in the palisade layer directly beneath the stomata.

Aerial leaves generally have an appreciable number of stomata on the lower surface, but the stomata are more abundant on the upper surface (see *Table I*). In only one specimen was the frequency greater below than above. Although the frequency of stomata on a single surface is fairly constant, it may vary from plant to plant in a species, and the relative number of stomata on the upper and lower surfaces may also vary. Presumably this intraspecific variation is largely ecologically controlled.

Interspecific variation in stomatal frequency is quite pronounced in some cases. The number of stomata per unit area (0.0715 mm²) on the upper epidermis ranges from 13 to over 40, although most are below 30.

Gupta (1957) noted that the species he examined could be distinguished in some cases on the basis of relative stomatal abundance. *Marsilea vestita*, for example, was reported to have three to four times as many stomata as many of the other species. Our data do not confirm this, for we did not find *M. vestita* to have an exceptionally large number of stomata. In fact, one specimen with larger than normal stomata had exceptionally few. *Marsilea mexicana* had more abundant stomata than any other species we examined.

TABLE I. STOMATAL FREQUENCY AND SIZE IN MARSILEA

Species & Collector	*Frequency*		*Size (Microns)*	
	Upper	*Lower*	*Upper*	*Lower*
M. BERTEROI A. Braun—Puerto Rico				
Britton et al. 8872	18.2	17.0	22.5	26.8
Sintenis 3805	19.0	15.6	21.6	24.3
M. FOURNIERI C. Chr.—Mexico				
Brandegee, 5 Sept 1893	30.8	19.0	20.8	25.0
Brandegee, 16 Oct 1899	32.4	25.8	20.2	23.5
Carter & Moran 5394	20.8	18.0	21.1	24.2
Pringle 2434	17.8	10.8	27.9	29.6
Wiggins 5422	17.6	11.2	25.2	27.9
M. MACROPODA Engelm.—Texas				
Palmer 11245	20.2	16.0	25.2	25.7
Palmer 33856	12.8	14.4	23.2	26.8
M. MEXICANA A. Braun—Honduras & Mexico				
Glassman 2054	34.2	1.8	22.8	23.5
Pringle 2007	37.8	0	20.8	—
M. MOLLIS Robins. & Fern.—Mexico				
Hartman 604	22.8	12.4	21.6	24.1
Palmer 13	22.2	14.0	27.3	29.9
M. MUCRONATA A. Braun—Kansas & Texas				
Kolstad & Harms 1581	29.4	17.8	24.9	29.2
Tharp, 30 May 1937	22.2	17.2	22.7	26.1

TABLE I. STOMATAL FREQUENCY AND SIZE IN MARSILEA (*Continued*)

Species & Collector	*Frequency*		*Size (Microns)*	
	Upper	*Lower*	*Upper*	*Lower*
M. NASHII Underw.—Bahamas				
Nash & Taylor 1411	22.4	14.0	30.2	34.6
M. OLIGOSPORA Goodd.—Idaho & Wyoming				
Nelson & Macbride 1158	26.2	18.2	21.9	28.0
Payson & Payson 2920	24.4	21.0	22.6	26.4
Porter & Porter 9399	19.4	15.4	23.8	24.9
M. POLYCARPA Hook. & Grev.—Puerto Rico				
Britton et al. 6726	26.2	17.8	19.7	20.9
M. QUADRIFOLIA L.—Ontario, Mass. & Cult.				
Miller 647	29.4	0	22.1	—
Moldenke 4608	17.8	6.8	22.4	23.6
Seymour, Aug 1900	19.2	17.2	21.0	21.9
M. TENUIFOLIA Englem.—Texas				
Tharp, 11 Aug 1941	19.6	17.6	26.5	29.1
M. UNCINATA A. Braun—Texas				
Tharp, 3 Nov 1928	23.0	19.2	20.7	26.5
M. VESTITA Hook. & Grev.—Idaho, Calif. & Utah				
Christ 19130	14.2	9.6	26.8	28.8
Heller 11633	20.0	18.2	25.1	26.4
Tillett 185	19.8	16.0	33.5	38.2

STOMATAL SIZE

Stomatal sizes were determined by measuring 20 stomata on each surface. Averages are shown in *Table I*. In every plant the stomata of the lower surface were found to be larger than those of the upper epidermis. Generally the difference is only 1–3 μ, but occasionally it is more pronounced, as in *M. uncinata* and one specimen of *M. oligospora*. Certain species are outstanding in their very small stomata (*M. polycarpa*) or very large stomata (*M. nashii*), but most species have stomata 23–30 μ long.

Within species there is generally relative uniformity, although considerable variation is seen in *M. fournieri*, *M. mollis*, and *M. vestita*. A polyploid series has been reported in *M. minuta* of India (Mehra and Loyal, 1959), a species for which Gupta (1962) reports stomatal size differences.

CONCLUSION

Our study has shown that considerable variation exists in the epidermis of *Marsilea* species, at least some of which has taxonomic significance. However, in order to determine more definitely the meaning of this variation, plants need to be grown under controlled conditions to determine the effects of water and light on the numbers and location of stomata; more extensive sampling is needed to establish the limits of variation within species; and more cytological information would be helpful in assessing the role that polyploidy plays in controlling stomatal size.

LITERATURE CITED

GAUDET, J. J. 1964a. Morphology of Marsilea vestita I. Ontogeny and morphology of the submerged and land forms of the juvenile leaves. Amer. J. Bot. **51**: 495–502.

———. 1964b. Morphology of Marsilea vestita II. Morphology of adult and submerged leaves. Amer. J. Bot. **51**: 591–597.

GUPTA, K. M. 1957. Some American species of Marsilea with special reference to their epidermal and soral characters. Madroño **14**: 113–127.

———. 1962. Marsilea. Botanical Monograph No. 2. Council of Scientific and Industrial Research, New Delhi.

HITCHCOCK, C. L., A. CRONQUIST, M. OWNBEY and J. W. THOMPSON. 1969. Vascular Plants of the Pacific Northwest, Pt. 1. Univ. of Washington Press, Seattle.

KNOBLOCH, I. W. and D. S. CORRELL. 1962. Ferns and Fern Allies of Chihuahua, Mexico. Texas Research Foundation, Renner.

MEHRA, P. N. and D. S. LOYAL. 1959. Cytological studies in Marsilea with particular reference to Marsilea minuta L. Res. Bull. Panjab Univ. n.s., **10**: 357–374.

REED, C. F. 1954. Index Marsileata et Salviniata. Bol. Soc. Brot. II, **28**: 1–61.

VAN COTTHEM, W. 1970. Comparative morphological study of the stomata in the Filicopsida. Bull. Jard. Bot. Nat. Belg. **40**: 81–239.

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The American Species of Plagiogyria sect. Carinatae[1]

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Plagiogyria is principally a genus of China and adjacent regions, and is usually said to have about a dozen species in the New World. These species and their nomenclature have never been adequately studied in the past, although Copeland (1929) attempted to distinguish them and named several new species. Ching (1958) has written an extensive treatment of the species found on the Asiatic mainland.

Among ferns, *Plagiogyria* is unusual in having few or no trichomes at maturity. Young portions of the plants are covered with mucilage which is secreted by many, deciduous or inconspicuous, glandular hairs. In the Asiatic species studied by Hennipman (1968), the hairs are usually less than 1 mm long. Scales are absent, although patches of matted hairs and mucilage sometimes resemble the "amorphous" scales characteristic of a few species of *Blechnum*. *Plagiogyria* is unique among the leptosporangiate ferns in having sporangia with complete, oblique annuli and about 48 spores in each sporangium. The characters of the gametophyte are predominantly primitive, according to Stokey and Atkinson (1956). It is clearly an isolated genus, and in recent years has been put in its own family or order.

The sterile fronds of the American species of sect. *Carinatae*, which supply all of the key characters, vary considerably within each species. The differences between the species are subtle, and immature or aberrant specimens may be difficult to place accurately; there seem to be no useful characters beyond those mentioned in the keys. Because of the size overlap between extreme specimens of the various species and the general similarities of their fronds, descriptions are of little use, and so have not been included in this paper.

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[1] Partial cost of publication of this paper has been borne by the Smithsonian Institution.

[2] I wish to thank the curators of the herbaria from which I borrowed or examined specimens for their cooperation.

Most of the New World species of *Plagiogyria* are quite restricted in distribution: one is from Hispaniola, one from Jamaica, one from Mexico, one from Costa Rica to Bolivia, and one from southeastern Brazil. The only widespread American species, *P. semicordata*, is found in Cuba and Jamaica and from Mexico southward to Venezuela and Bolivia. All of the species are terrestrial at middle and upper altitudes in moist, cool mountains and are absent from coastal and interior lowlands.

Plagiogyria sect. **Carinatae** Ching ex Lellinger, sect. nov.[3]

Terrestrial ferns up to ca. 1 m tall, with erect, dimorphic fronds clustered at the tip of erect, woody, atrichomatous, dictyostelic rhizomes up to ca. 15 cm long and 1.5 cm in diam. (exclusive of the crowded and persistent stipe bases). Stipes and rhachises stramineous, brownish near the stipe base. Stipes 5–30 cm long, usually triangular, sulcate, only slightly expanded at the base; vascular bundles 3 at the base, fusing into a single V-shaped and then an U-shaped trace, this becoming nearly ribbon-shaped in the rhachis; aerophores obsolete on the dorsal surface of the stipe bases or absent. Fronds devoid of scales, with mucilage-producing, glandular hairs when young, deeply pinnatifid (or the fertile sometimes pinnate), usually lanceolate, linear-lanceolate, or narrowly lanceate; rhachises terete below, sulcate above. Sterile fronds herbaceous or subcoriaceous; pinnae up to 15 cm long, (3)5–10(12)

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[3] Until now the name *Plagiogyria* sect. *Carinatae* and the names of the subsections proposed by Ching (Acta Phytotax. Sinica **7**: 135. 1958) have been invalid. Although they were in proper form and were provided with Latin diagnoses, the conditions of Art. 37 of the Code, which became effective about five months before Ching published, were not fulfilled. I therefore wish to validate these names by publishing type species for them:

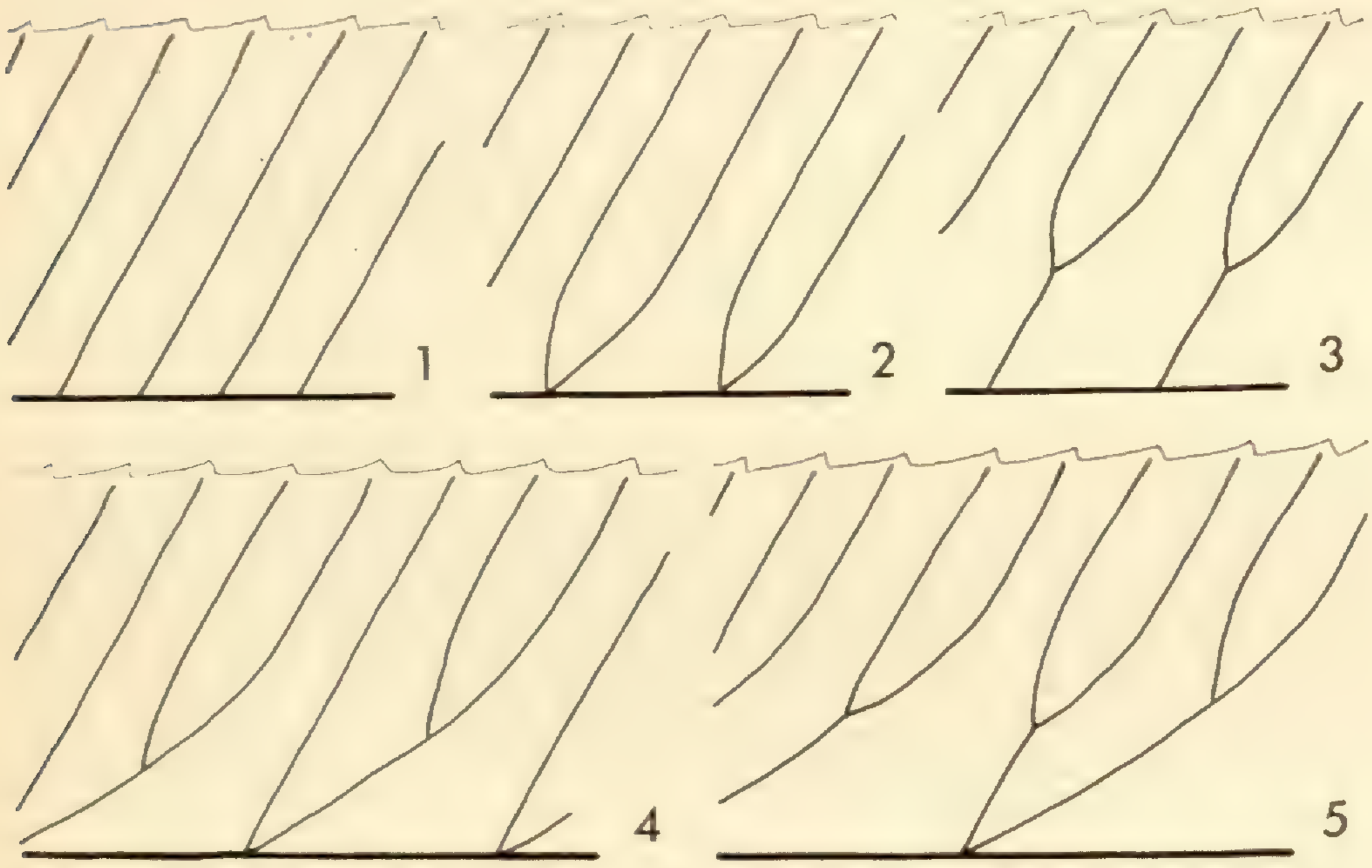
Plagiogyria subsect. **Adnatae** Ching ex Lellinger, subsect. nov. Type species: *Lomaria adnata* Blume [= *Plagiogyria adnata* (Blume) Bedd.].

Plagiogyria subsect. **Euphlebiae** Ching ex Lellinger, subsect. nov. Type species: *Lomaria euphlebia* Kunze [= *Plagiogyria euphlebia* (Kunze) Mett.].

Plagiogyria subsect. **Pycnophyllae** Ching ex Lellinger, subsect. nov. Type species: *Lomaria pycnophylla* Kunze [= *Plagiogyria pycnophylla* (Kunze) Mett.].

Ching also proposed sect. *Euplagiogyrae*, which is superfluous; according to Art. 22 of the Code, the typical section must be an automatic tautonym repeating without citation of authority the name of the genus, i.e., sect. *Plagiogyria*.

mm wide, the margins subentire or crenate to sharply serrate or doubly so, the veins solitary or paired at the base and simple or 1-forked (see *Figs. 1–5*). Fertile fronds herbaceous, generally longer and narrower and with longer stipes and shorter laminae than the sterile fronds; pinnae up to 12(15) cm long, 2–4 mm wide,



DIAGRAMS OF VENATION TYPES IN THE AMERICAN SPECIES OF PLAGIOGYRIA SECT. CARINATAE. FIG. 1. SIMPLE. FIG. 2. PAIRED AT THE BASE. FIG. 3. FORKED ABOVE THE BASE. FIG. 4. PAIRED AT THE BASE WITH ONE BRANCH FORKED ABOVE THE BASE. FIG. 5. PAIRED AT THE BASE WITH BOTH BRANCHES FORKED ABOVE THE BASE.

the margins entire or irregular, often thin, somewhat involute, the veins 1-forked and sometimes uniting with an adjacent vein at the tip or forming a continuous commissure; receptacles somewhat enlarged and thickened; sori elongate; sporangia large, the stalk long, of 4–6 rows of cells, the capsule laterally compressed, the annulus oblique, continuous; spores 48 per sporangium, tetrahedral, tuberculate to nearly smooth; x = ca. 25.

TYPE SPECIES: *Plagiogyria argutissima* Christ.

KEY TO THE AMERICAN SPECIES OF PLAGIOGYRIA SECT. CARINATAE

Pinnae of sterile fronds 5–7(8) mm wide; veins simple and either solitary or paired at the costae, or veins simple and 1-forked (*Figs. 1–3*).

Margins of sterile pinnae simply serrate, the veins beneath usually at least slightly prominulous (MEXICO) . . . . . 2. *P. pectinata*

Margins of sterile pinnae crenate to doubly serrate, the veins beneath not prominulous (BRAZIL) . . . . . 3. *P. fialhoi*

Pinnae of sterile fronds (7)8–12 mm wide; veins solitary and 1-forked or paired at the costae and 0–2-forked (*Figs. 2–5*).

Sterile fronds decidedly narrowed at the base, the basal pinnae no more than half as long as the longest pinnae. Sterile fronds 6–14(22) cm wide,[4] the pinna margins usually biserrate, at least toward the apex (JAMAICA, CUBA, MEXICO to VENEZUELA and BOLIVIA).

1. *P. semicordata*

Sterile fronds not much narrowed at the base, the basal pinnae about two-thirds as long as the longest pinnae. Sterile fronds 10–24(30) cm wide.

Sterile fronds (10)13–24(30) cm wide[5] (COSTA RICA to BOLIVIA).

4. *P. costaricensis*

Sterile fronds 10–15(18) cm wide.

Sterile pinnae crenate-serrate mostly toward the apex, subentire toward the base; laminae mostly 15–18 cm wide (JAMAICA) . . . . . 5. *P. maxonii*

Sterile pinnae sharply and evenly serrate throughout; laminae mostly 10–15 cm wide (HISPANIOLA) . . . . . 6. *P. serrulata*

1. PLAGIOGYRIA SEMICORDATA (Presl) Christ, Farnkr. 176. 1897.

Lomaridium semicordatum Presl, Epim. Bot. 155. 1849 [1851]. TYPE: Colombia, *sin coll.* (presumably PR or PRC not seen).

Plagiogyria biserrata Mett. Abhandl. Senckenb. Naturforsch. Gesell., Frankfurt **2** [Farng. Plag. 8]: 272, *t. 15, f. 1–18*. 1858. LECTOTYPE: "Reg. alpina," Colonia Tovar, Venezuela, *Moritz 400* (B not seen Morton photo 10211; isolectotypes HBG not seen Morton photo 5339, US), chosen by Copeland (1929, p. 409). The other syntypes are Mexico, *Karwinsky* (B not seen) and "Hautes Andes de Truxillo et de Mérida," alt 4000–4500 ft, *Linden 556* (B not seen; isosyntype BR Weatherby photo US). The latter specimen I identify as *P. costaricensis*.

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[4] Sterile fronds 6–8(12) cm wide in South America, 8–12(15) cm wide in the West Indies, and 8–14 cm wide in Central America, with some specimens from Oaxaca and Morelos, Mexico, up to 22 cm wide.

[5] Sterile fronds 12–20 cm wide in South America, (9)12–15(30) cm wide in Costa Rica.

Plagiogyria obtusa Copel. Phil. J. Sci. **38:** 413. *t. 13*. 1929. TYPE: Near Pico Turquino, Cuba, *León 11126* (US; isotype NY).

RANGE AND HABITAT: Mountains of Cuba and Jamaica (alt 1650–2220 m), of Mexico (Morelos and Puebla to Chiapas), Guatemala, Costa Rica, and Panama (alt 2500–3150 m), and of Venezuela, Colombia, Ecuador, Peru, and Bolivia (alt 2500–3500 m), in moist, often shady places in coniferous or hardwood forests and subpáramo areas.

Plagiogyria semicordata has biserrate pinnae that are narrower than those of *P. costaricensis*, which are broader and denticulate. The sterile pinnae of *P. pectinata*, in contrast, are simply serrate. The apex of the sterile fronds of *P. semicordata* is more tapering than is that of *P. costaricensis*. It is possible that most of the South American specimens I have identified as *P. semicordata*—particularly those not from Venezuela—are small, contracted, and somewhat aberrant specimens of *P. costaricensis*, but I have no proof of this.

REPRESENTATIVE SPECIMENS EXAMINED: **Cuba:** ORIENTE: Pico Turquino, alt 2000 m, *Seifriz 1091* (US), northern spur, alt 1850 m, *Ekman 5465* (NY, US), alt 2040 m, *Ekman 5496, 14546* (both US). **Jamaica:** Blue Mountain Peak, alt 2100–2225 m, *Maxon 1413* (US), *Underwood 2538* (NY), summit, alt 2100–2200 m, *Maxon 9875* (NY, US); Between Portland Gap and Blue Mountain Peak, alt 5500–7400 ft, *Wilson & Webster 623* (US); unlocalized, *Gilbert 225* (NY), *Hart 188* (US).

Mexico: VERACRUZ: Orizaba, *Müller* in 1855 (NY). PUEBLA: Honey Station, *Pringle 15703* (F, US). MORELOS: Zempoala, *Lyonnet 1419* (US). OAXACA: Cerro San Felipe, alt 3000 m, *Conzatti 677* (US); Sierra de Clavellinas, alt 9000 ft, *Pringle 4999* (NY, US). CHIAPAS: Cerro Hueytepec, 5 km NW of Ciudad de Las Casas (San Cristóbal), alt 8800 ft, *Little & Sharp 9947* (US). **Guatemala:** HUEHUETENANGO: Cerro Cananá, between Nucapuxlac and Cananá, Sierra de los Cuchumatanes, alt 2500–2800 m, *Steyermark 49090* (F, US). **Costa Rica:** CARTAGO: S slope of Volcán Turrialba, near the Finca del Volcán Turrialba, alt ca. 2000–2400 m, *Standley 35133* (US); Behind the Hotel La Georgina, near Villa Mills, alt 2900 m, *de la Sota 5100* (US), alt 3000 m, *A. Jiménez M. 3401* (F). SAN JOSÉ: Cerro de las Vueltas, alt 3000 m, *Standley 43883* (US). **Panama:** Volcán Chiriqui, above El Potrero Camp, alt 2890–3025 m, *Maxon 5334* (US).

Venezuela: ARAGUA: Near Colonia Tovar, *Fendler 325* (F, NY). **Colombia:** ANTIOQUIA: Highland of Santa Rosa, alt 2500–2700 m, *Lehmann* (US). CUNDINAMARCA: Macizo de Bogotá, Quebrada de Chicó, alt 2800–3000 m, *Cuatre-*

casas 5511 (US); Near La Gruta, Bogotá, *Little & Little 7848* (US); Guadalupe, 5 km E of Bogotá, *Little & Little 9184* (US), *Haught 5659* (F, NY, US). **Ecuador:** AZUAY: Páramo de Tinajillas, 30–50 km S of Cuenca, alt 11000–11500 ft, *Camp E-2225* (F, NY, US). **Peru:** AMAZONAS: Summit of Puma-urcu SE of Chachapoyas, alt 3100–3200 m, *Wurdack 1159* (F, NY, US). **Bolivia:** LA PAZ: North Yungas, Unduavi, alt 3500 m, *Buchtien 2146* (US).

2. PLAGIOGYRIA **pectinata** (Liebm.) Lellinger, comb. nov.

Lomaria pectinata Liebm. Vid. Selsk. V, 1:233 [seors. 81]. 1849. TYPE: Cerro de Sempoaltepec, Oaxaca, Mexico, alt 8000–9000 ft, *Liebmann* (C not seen).

Lomaria arguta Fée, Mém. Soc. Hist. Nat. Strasb. 5 [8 Mém.]: 70. 1857. TYPE: "Vallée d'Orizaba," Cerro del Agua, Veracruz, Mexico, alt 2700m, *Schaffner 98* (P? not seen).

Plagiogyria aequidentata Fourn. Mex. Pl. 1: 133. 1872. TYPE: Orizaba, Veracruz, Mexico, *F. Müller 723* (Hb. Lenormand not seen). The brief description, which contrasts the simply serrate pinnae with *P. biserrata* Mett. (a synonym of *P. semicordata*), is sufficient to place the name.

Plagiogyria arguta (Fée) Copel. Phil. J. Sci. **38:** 407. 1929.

RANGE AND HABITAT: Hillsides and mountains of northern and central Mexico (Chihuahua to Jalisco, Morelos, and Puebla), at 1750–3200 m altitude, in shaded, moist places in coniferous and coniferous-hardwood forests.

Generally the basal pinnae of the sterile fronds of *P. pectinata* are about half as long as the longest pinnae, but in specimens from Oaxaca, Mexico, the sterile fronds have the lower pinnae even more reduced.

ADDITIONAL SPECIMENS EXAMINED[6]: **Mexico:** CHIHUAHUA: Near La Rocha, NE slope of Sierra Mohinora, alt 7500 ft, *Correll & Gentry 23112* (US); Mojarachic, *Knobloch 5947* (US). DURANGO: San Ramón, *Palmer 124* (NY, US). JALISCO: E of Mamantlán ca 15 mi SSE of Autlán by way of Chante, alt 8300 ft, *Wilbur & Wilbur 2001* (US); near Etzatlán, *Rose & Painter 7598* (NY, US). HIDALGO: Beside the Río Teponapa, vicinity of Zacualtipán, alt 2000 m, *Moore 3207* (US). PUEBLA: Near Honey Station, alt 5800 ft, *Pringle 8958* (F, NY, US). MORELOS: Lagunas de Zempoala, *Bro. Sanchez S. 466* (US). MEXICO: La Juntas, Sultepec Road, alt 3200 m, *Lyonnet 3119* (US); Zempoala, alt 3200 m, *Matuda 28140* (US); Cerro de Acatitlán, alt 2000 m, *Matuda 30762*

[6] The specimens (from Oaxaca south to Chiapas and adjacent Guatemala) differ from typical *P. pectinata* in having the lower pinnae of their sterile laminae reduced gradually below to 0.5–1 cm long, or even to mere auricles; typical specimens (from Oaxaca north to Chihuahua) have the lowest pinnae 0.35–0.65 as long as the longest ones.

(US); Crucero, 11 Nov 1934, *Hinton 6823* (NY, US); Los Hornos, alt 2700 m, *Hinton 2808* (NY); Nanchititla, *Hinton 3600* (NY). OAXACA: Sierra de Clavellinas, alt 9000 ft, *C. L. Smith 2063* (NY, US); Valley of the Río Yelagago, ca. 20 mi. NE of Villa Alta, alt 6800–7200 ft, *Mickel 929* (US); N slope of Cerro Pelón, along road from Ixtlán toward Tuxtepec, alt 9000 ft, *Mickel 1142* (US). CHIAPAS: Zonehuitz, *Münch 102* (US); between San Cristóbal las Casas and Tenejapa Center, alt 8400 ft, *Breedlove 12907* (US); Barrio of Tuk, paraje of Matsab, Municipio of Tenejapa, alt 7500 ft, *Breedlove 12565* (US). **Guatemala:** HUEHUETENANGO: Top of Cerro Chemalito, Sierra de los Cuchumatanes, 3.5 mi. W of Santa Eulalia, alt 3100–3150 m, *Steyermark 49927* (F, US).

3. PLAGIOGYRIA FIALHOI (Fée & Glaziou in Fée) Copeland, Univ. Calif. Publ. Bot. **19:** 297. 1911.

Lomaria fialhoi Fée & Glaziou in Fée, Crypt. Vasc. Brés. **1:** 239, *t. 7. f. 2.* 1869. TYPE: Serra os Orgãos, Est. Rio de Janeiro, Brazil, *Glaziou 3326* (P not seen).

DISTRIBUTION AND HABITAT: Southeastern Brazil, in the high portions of mountains, in low forests, according to Lehnem (1967).

ADDITIONAL SPECIMENS EXAMINED: **Brazil:** SANTA CATARINA: Source of the Rio de Oratório, alt 1200 m, *Smith & Reitz 10232* (US); Campo dos Padres between Fazenda Santo Antônio and Fazenda Campo dos Padres, alt 1400–1650 m, *Smith & Reitz 10377* (US).

4. PLAGIOGYRIA COSTARICENSIS Mett. ex Kuhn, Linnaea **36:** 149. 1869.

Plagiogyria anisodonta Copel. Phil. J. Sci. **38:** 409, *t. 9.* 1929. TYPE: Dead crater of Volcán Poas, Prov. Alajuela, Costa Rica, alt 2800 m, *O. Jiménez 1018* (US). PARATYPES: Volcán Poas, Prov. Alajuela, Costa Rica, upper slopes between the Hotel and the crater, alt 2500–2640 m, *Standley 34895* (US), summit, alt 2644 m, *Tonduz 10714* (US).

Plagiogyria denticulata Copel. Phil. J. Sci. **38:** 412, *t. 12.* 1929. TYPE: "Im Nebelwald des Bergkammes der Laguna verde bei Comparapa [Comarapa]," Depto. Santa Cruz, Bolivia, alt 2600 m, *Herzog 1954* (US). PARATYPE: North Yungas, Bolivia, alt 3300 m, *Buchtien 1908* (US).

Plagiogyria latifolia Copel. Phil. J. Sci. **38:** 411, *t. 11.* 1929. TYPE: Cani, 7 mi. NE of Mito, Depto. Huánuco, Peru, alt ca. 8500 ft, *Macbride 3432* (US; isotype F).

TYPE: Volcán Barba, Prov. Heredia, Costa Rica, *Wendland 1066* (C? not seen) A drawing of the holotype (B) illustrates the broad, coarse, sterile lamina and the fertile lamina only slightly reduced at the base.

Distribution and habitat: Mountains of Costa Rica and the Andes, above (1200)1800 m altitude, in wet woods and shrubby páramos.

This species is larger and coarser than *P. semicordata*. The costae beneath often have what look like rather amorphous scales along them, but these are merely dried up patches of mucilage which have trapped numerous deciduous hairs. Sometimes a few cells from deciduous glands can also be seen; their terminal cells are swollen and reddish-brown.

Additional specimens examined: **Costa Rica:** Alajuela: Volcán Poas, near the summit at the edge of the crater, *Burger 4352* (NY), upper lagoon, alt 2564 m, *Pittier 2970* (US), Poas Lake, alt 8590 ft, *Stork 2338* (US , along the road to the volcano, alt 6000–7000 ft, *Scamman 7607* (US). Heredia: Volcán Barba, alt 2700 m, *Valerio 146* (US). Cartago: La Pastora, near Volcán Irazu, alt 9000 ft, *Stork 2378* (US ; N of Volcán Irazu, alt 10000 ft, *Stork 1284* (NY); Volcán Turrialba, alt 3100 m, *Torres R. 12* (US . San José: Cerro de las Vueltas, alt 2700–3000 m, *Standley & Valerio 43540* (US), alt 3000 m, *Pittier 10498* (US ; Laguna de la Chonta, NE of Santa María de Dota, alt 2000–2100 m, *Standley 42129* (US).

Venezuela: Mérida: Upper Andes of Truxillo and Mérida, Culata, alt 1600 toises [= 10240 ft], *Linden 556* [a syntype of *P. biserrata* Mett.] (B not seen; BR Weatherby photo US). **Colombia:** Cundinamarca: SE of Bogotá, alt 2800 m, *Andre 975* (NY); Usaquén, near Bogotá, alt 2700 m, *Uribe U. 208* (F); Quebrada de las Delicias, Macizo de Bogotá, alt 2650–2770 m, *Cuatrecasas 5465* (F, US); Summit of Monserrate, E of Bogotá, *Little & Little 8189* (US); Western slopes of Páramo de Cruz Verde, alt 3150 m, *Cuatrecasas 402* (US). **Nariño:** Headwaters of the Río Tellez, above Soledad, alt 2900–3150 m, *Ewan 16513* (US). **Peru:** Huánuco: Yanano, alt ca 6000 ft, *Macbride 3830* (F, US). **Bolivia:** La Paz: North Yungas, Unduavi, alt 3200 m, *Buchtien 410* (F, NY), alt 3300 m, *Buchtien 2156* (US), *2677* (F).

5. Plagiogyria maxonii Copel. Phil. J. Sci. **38:** 411, *t. 11*. 1929.

Type: Summit of Blue Mountain Peak, Jamaica, alt 2100–2200 m, *Maxon 9910* (US; isotypes F, NY).

Distribution and habitat: Mountains of Jamaica, in wet forest above 1700 m altitude.

Additional specimens examined: **Jamaica:** Sir Johns Peak, *Watt 5* in 1910 (NY, US); Mossman's Peak, upper eastern ridge and summit, alt 1700–1925 m, *Maxon 9721* (F, NY, US); Blue Mountain Peak, alt 6500–7325 ft, *Underwood 1495* (NY), alt 7000–7423 ft, *Maxon 1439* (US), *Underwood 2554* (NY), alt 7420 ft, *Harris 7144* (F).

6. PLAGIOGYRIA **serrulata** (Willd.) Lellinger, comb. nov.

Acrostichum serrulatum Willd. Sp. Pl. ed. 4, **5:** 113. 1810. Based on *Plate 81, Polypodium fuscum tenuissimis denticulis serratum,* of Plumier's "Tractatus de Filicibus Americanis." Plumier's plate illustrates several characteristics of this species (or of *Plagiogyria* in general): the evenly serrate pinnae with 1-forked veins, the acrostichoid fertile frond, and the sterile fronds scarcely narrowed below. His description mentions the blackish rhizome and the rhizome hairs, which are also characteristic of *Plagiogyria*, but not of *Polypodium*, to which Plumier ascribed his plant. He gives the locality as "la bande du Sud au Grand Cul-de-sac, proche un endroit que les Boucaniers appellent le fond épineux" [Haiti].

Blechnum urbanii Brause in Urban, Symb. Antill. **7:** 157. 1911, as "*urbani.*" TYPE: Near Constanza, Santo Domingo, alt 2200 m, *von Türckheim 3408* (B not seen photo US, fragment US).

Plagiogyria urbanii (Brause) Copel. Phil. J. Sci. **38:** 413. 1929.

DISTRIBUTION AND HABITAT: Mountains of Hispaniola, in mossy and marshy places in pine forests above 1850 m altitude.

ADDITIONAL SPECIMENS EXAMINED: **Dominican Republic:** Sierra de Ocoa, San José de Ocoa, Loma Sucia, alt ca 2300 m, *Ekman H12002* (US); Cordillera Central, Monción, high ridge between the Río Cerrobi and the Río San Juan, alt ca 1900 m, *Ekman H12790* (US); Sabana Nueva, between Piedra del Aguacate and Río del Oro, alt 6200 ft, *Howard & Howard 9123* (NY, US). **Haiti:** Massif de la Hotte, Torbec, top of Morne Formon, *Ekman H7501* (NY, US).

LITERATURE CITED

CHING, R. C. 1958. The fern genus Plagiogyria on the mainland of Asia. Acta Phytotax. Sinica **7:** 105–154, *t. xxviii–xl.*

COPELAND, E. B. 1929. The fern genus Plagiogyria. Phil. J. Sci. **38:** 377–417, *t. 1–15.*

HENNIPMAN, E. 1968. The mucilage secreting hairs on the young fronds of some leptosporangiate ferns. Blumea **16:** 97–103.

SEHNEM, A. 1967. Plagiogiriáceas *in* R. Reitz, Flora Ilustrada Catarinense, Parte I. Itajaí, Brazil.

STOKEY, ALMA G. and LENETTE R. ATKINSON. 1956. The gametophytes of Plagiogyria glauca (Bl.) Mett. and P. semicordata (Pr.) Christ. Phytomorphology **6:** 239–249.

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The Genus Stenochlaena J. Smith with Description of a New Species

R. E. HOLTTUM

The genus *Stenochlaena* in Christensen's "Index Filicum" (1905) included species belonging to three distinct genera. The three are superficially alike in having simply pinnate fronds with entire pinnae and free veins, the fertile fronds having narrow pinnae almost completely covered beneath with sporangia. But if one examines the vascular anatomy, scales and spores, one finds the superficial similarity hides a great diversity. The three genera are *Stenochlaena* s.str., *Lomariopsis* Fée, and *Teratophyllum* Mett. I studied these plants in the forests of Malaya, and wrote a paper describing their differences (Holttum, 1932). The differences are also summarized by Copeland (1947), and the species of the three genera in the Malay Peninsula are described in Holttum, 1954. The genera *Stenochlaena* and *Teratophyllum* are confined to the Old World, but *Lomariopsis* is pantropic. Thus all tropical American species formerly included in *Stenochlaena* belong to *Lomariopsis* (see Holttum, 1939), but Vareschi (1968) still places them in *Stenochlaena*, and his generic description includes a statement about vascular anatomy which applies to *Stenochlaena* s.str. and is not true of the species he describes. In 1932 I expressed an opinion that *Stenochlaena* is related to *Acrostichum* (both genera have an exceedingly complex vascular anatomy) and thus to *Pteris*, and I still think this possible; but Copeland has included *Stenochlaena* in the Blechnaceae. *Lomariopsis* and *Teratophyllum* appear to me to be related to *Tectaria* and *Ctenitis*.

Six species of *Stenochlaena* are here recognized, two in Africa, the others in Asia, Malesia, and the Pacific. One of the latter has not yet received a valid name; as pointed out by Morton (1970) my attempt to give it one ignored the terms of the International Code of Botanical Nomenclature. In my paper of 1969 I also reported that examination of a type specimen in Presl's herbarium necessitated a re-interpretation of his name *S. juglandi-*

folia and therefore a re-naming of specimens previously so called by me. As a comprehensive account of all species of the genus as now understood has never been published, I take this opportunity of providing one, to include the information of my paper of 1969. Only important synonyms and brief species descriptions are included. Further details may be found in the other literature cited.

KEY TO THE SPECIES OF STENOCHLAENA

Fertile fronds bipinnate, the sterile simply pinnate. . . . . 1. *S. tenuifolia*
Fertile and sterile fronds both simply pinnate.
  Pinnae commonly 15 pairs or more, the sterile pinnae to at least 15 × 3 cm; fertile pinnae with very narrow sterile margin.
    Scales on tip of rhizome narrow, spreading; bases of pinnae not articulate . . . . . 2. *S. mildbraedii*
    Scales on tip of rhizome almost circular, appressed; pinnae articulate or not.
      Lower pinnae at least, appearing fully articulate when dry; pinna-bases cuneate; fertile pinnae 2–3 mm wide; spores evenly tuberculate throughout. . . 3. *S. palustris*
    Pinnae not distinctly articulate; sterile pinnae with broadly rounded to cordate bases; fertile to at least 5 mm wide; spores with raised ± broken ridges.
      Sterile pinnae broadly rounded at base, sometimes partly articulate; fertile pinnae 5 mm wide; spores with irregular broken ridges. . . . . 4. *S. milnei*
      Sterile pinnae cordate at base, not at all articulate; fertile pinnae 7–10 mm wide; spores with parallel continuous or broken ridges. . . . . 5. *S. cumingii*
  Pinnae to 7 pairs; sterile pinnae to 10 × 2.2 cm; fertile pinnae 3 mm wide with thin reflexed sterile margins 1 mm wide. . . . . 6. *S. areolaris*

1. STENOCHLAENA TENUIFOLIA (Desv.) Moore, Gard. Chron. **1856:** 193; Morton, Amer. Fern Journ. **55:** 165. 1965; Tardieu in Humbert, Fl. Madag., Fam. 5, 1: 110. 1958.

Lomaria tenuifolia Desv. Berlin Naturf. Freund. Mag. **5:** 326. 1811.

Rhizome to 12 mm diameter; scales on rhizome-tip narrow, spreading; sterile pinnae very variable in size, to 30 × 3 cm, not at all articulate to rachis; fertile pinnae to 15 cm long with 10–12 pairs or more of pinnules ca. 5 cm × 2 mm.

DISTRIBUTION: East tropical to South Africa, Madagascar, Mauritius.

2. STENOCHLAENA MILDBRAEDII Brause, Bot. Jahrb. Engler **53:** 384. 1915; Tardieu in Flore du Cameroun **3:** 353, *pl. XXXIV, figs. 5, 6*. 1964.

Rhizome-scales elongate and spreading; stipe 100–150 cm; frond 100–150 cm long; sterile pinnae 16–25 pairs, to 40 × 4 cm, not articulate to rachis; fertile pinnae 4–5 mm wide.

DISTRIBUTION: West Africa, Cameroons to Angola, eastwards to Uganda; climbing on *Raphia* palms.

3. STENOCHLAENA PALUSTRIS (Burm. fil.) Bedd. Ferns Brit. Ind. Suppl. 26. 1876. Handb. Ferns Brit. Ind. 421. 1883. Holttum, Rev. Fl. Malaya **2:** 412, fig. 241. 1954.

Polyopdium palustre Burm. fil. Fl. Ind. 234. 1768.
Lomaria ? juglandifolia Presl, Rel. Haenk. 52. 1825.
Stenochlaena fraxinifolia Presl, Epim. Bot. 163. 1851.
S. laurifolia Presl, *ibid.* 164 (see Holttum, 1969, pp. 14, 51).

Rhizome long-creeping or climbing, ca. 5–7 mm diameter; stipes 15–20 cm long containing up to 40 vascular strands; fronds 40–80 cm long with 8–15 pairs pinnae; sterile pinnae articulate to rachis, very variable in shape and size, commonly ca. 15 × 3 cm, exceptionally to 24 cm long but not proportionately wider, the base narrowly to broadly cuneate; fertile pinnae commonly 20 cm long and 2–3 mm wide, with a very narrow, not reflexed, sterile margin; spores evenly tuberculate throughout.

DISTRIBUTION: India through Malesia to N. E. Australia; in the Pacific to Samoa and Tonga.

4. STENOCHLAENA MILNEI Underwood, Bull. Torrey Bot. Club **33:** 38. 1906.

S. juglandifolia sensu Holttum, Gard. Bull. Str. Settl. **9:** 139. 1937, *non* Presl; Copel. Fern Fl. Philip. 428. 1960.

Resembling *S. palustris* but sterile pinnae always broadly rounded at base and articulation to rachis not complete; stipe of large fronds containing a larger number of vascular strands; fertile pinnae ca. 5 mm wide; spores bearing irregular broken ridges.

TYPE: Solomon Islands, *Milne 518* (K).

DISTRIBUTION: Philippines, New Guinea, Solomon Islands.

When I was in New Guinea in 1963, I noticed that this was the common species of *Stenochlaena* in the neighborhood of Lae, not *S. palustris*. It may be that the fern mentioned by Morton (1965, p. 166) as cultivated in the University of California Botanic Garden from spores collected in New Guinea is this species. Morton describes it as a large and coarse vine; *S. palustris* has a more slender rhizome and smaller fronds, and I would not so describe it.

5. STENOCHLAENA **cumingii** Holttum, sp. nov.

S. laurifolia sensu Holtt. Gard. Bull. Str. Settl. **5**: 259. 1932, *non* Presl; *ibid.* **9**: 141. 1937; Copel. Fern Fl. Philip. 428. 1960; Holttum, 1969, pp. 51, 52.

Stipes validus, basi fasces vasculares 100 vel ultra continens; pinnae steriles basi late cordatae, haud articulatae; pinnae fertiles 7–10 mm latae; sporae carinis ± interruptis parallelis longitudinalibus ornatae.

TYPE: Luzon, *Cuming 226* (K; isotype BM)

DISTRIBUTION: Moluccas, Philippines, New Guinea.

This appears to me to be a very distinct species, though Copeland has expressed doubts. *Stenochlaena milnei* is almost exactly intermediate between *S. palustris* and *S. cumingii* and may represent a hybrid. Cytological evidence is needed.

6. STENOCHLAENA AREOLARIS (Harr.) Copel. Philip. Journ. Sci. **2C**: 406. 1908; Fern Fl. Philip. 427. 1960.

Lomaria areolaris Harrington, Journ. Linn. Soc. Bot. **16**: 28. 1877.

Rhizome slender; stipe of sterile frond ca. 15 cm, of fertile ca. 30 cm long; sterile frond to 25 cm long with 7 pairs of pinnae; pinnae to 10 × 2.2 cm; fertile pinnae to 10 cm long, 3–6 mm wide, with thin margins 1 mm wide reflexed at right angles.

DISTRIBUTION: Philippines, New Guinea, climbing on *Pandanus*.

LITERATURE CITED

COPELAND, E. B. 1947. Genera Filicum. Waltham, Mass.

HOLTTUM, R. E. 1932. On Stenochlaena, Lomariopsis and Teratophyllum in the Malay Peninsula. Gard. Bull. Str. Settl. **5**: 245–323.

———. 1939. New species of Lomariopsis. Kew Bull. **1939**: 613–627.

———. 1954. A Revised Flora of Malaya, II Ferns of Malaya. Government Printer, Singapore.

HOLTTUM, R. E. 1969. A commentary on some type specimens of ferns in the herbarium of K. B. Presl. Nov. Bot. Inst. Bot. Univ. Carol. Prag. **1968**: 3–57.

MORTON, C. V. 1966. Observations on cultivated ferns, VIII. Stenochlaena. Amer. Fern. J. **55**: 164–166.

———. 1970. Review of "A commentary on some type specimens of ferns in the herbarium of K. B. Presl." Amer. Fern J. **60**: 119–128.

VARESCHI, V. 1968. Flora de Venezuela, Vol. I. Instituto Botánico, Caracas.

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The Variation in Spore Size and Germination in Dryopteris Taxa

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Fern spores have provided a series of diagnostic characters for understanding the biology and relationships of the species. A number of studies have demonstrated, for example, that 32 spores in a sporangium are characteristic of apogamous species (Manton, 1950). The size of spores within a genus is commonly related to the ploidal level of the species (Blasdell, 1963; Wagner, 1966; Whittier, 1970). Sterile hybrids tend to have a greater variation in spore size than normal sexual species (Wagner & Chen, 1965; Kanamori, 1969). It also has been demonstrated that some spores of sterile hybrids can germinate and produce gametophytes (Morzenti, 1967; deBenedictus, 1969). Recently, Weinberg and Voeller (1969) reviewed external factors that control germination of fern spores and, among other observations, they found that spores from the same plants taken at different times gave very different rates of germination.

[1] Research supported in part by NSF Grant GB-8113. Mr. Johannes Jensen prepared the spore materials for the experiments.

The woodferns, *Dryopteris*, present one of the most difficult of American fern complexes because of their tendency to hybridize. A number of workers have recently studied these plants cytologically and have shown that many of the sexual taxa share one or more genomes with others. Except for *D. fragrans*, *D. filix-mas*, and *D. marginalis*, all of the other sexual taxa have pairing affinities of the chromosomes with at least one other as shown in the following scheme (Wagner, Wagner, & Hagenah, 1969):

D. "dilatata"	DD
D. campyloptera	DDII
D. intermedia	II
D. spinulosa	IISS
D. cristata	SSLL
D. ludoviciana	LL
D. celsa	LLGG
D. goldiana	GG
D. clintoniana	SSLLGG

Some of these, e.g., *D. celsa*, are evidently of hybrid origin, but they behave exactly like normal species because of their balanced chromosome complements and normal spore and gametophyte production. Sterile hybrids in *Dryopteris*, on the other hand, have usually one or more "unmatched" chromosome sets, and the resulting failure of these sets to pair normally produces spore abortion and sterility.

The following investigation was undertaken to test the correlation of hybridity, spore size variation, and germinability in several *Dryopteris* species and hybrids grown under uniform conditions.

MATERIALS AND METHODS

The *Dryopteris* spores were obtained from plants in an experimental garden of the Matthaei Botanical Gardens at the University of Michigan. Since the plants were grown under the same conditions, environmentally produced variations in the spores or germination would be reduced to a minimum. In addition, the

cytology of the plants has been studied and the chromosome pairing at meiosis is known. The spores were collected July 22, 1969, by the following method. A pinna was removed and was washed with water to remove the foreign spores. The washed pinna was placed in an envelope to dry and to release the spores.

A sample (40 spores) was obtained from each taxon and measurements were made with a calibrated ocular micrometer. The standard deviation (Li, 1964) was taken as a measure of the variation in spore sizes. The total length of the spore, including the perispore, was measured because the endospore can not be observed in spores of some hybrids (Wagner & Chen, 1965). The spores were sown on 2 ml of Knudson's solution of mineral salts at pH 6.3 (Whittier, 1965) in capped, 1 dram vials. The cultural conditions included 12 hours of illumination (200 ft-c.) per day and a temperature of $24 \pm 1°$ C. Two hundred spores were observed seven days after sowing to determine the percentage of spore germination.

RESULTS AND DISCUSSION

Table I shows that the spores of the *Dryopteris* species had less variation in size, as measured by the standard deviation, than the spores of the *Dryopteris* hybrids. The germination of the spores of the *Dryopteris* species ranged from 78–95% with one exception. Spores of one plant of *D. celsa* had 37.3% germination. Hybrid spores had low percentages of germination with two exceptions, 34.7% for *D. celsa* × *marginalis* and 36.0% for one plant of *D. clintoniana* × *cristata*. These *Dryopteris* taxa demonstrate that a greater variation in spore size, which is mainly produced by spore abortion, is correlated with the sterile hybrids of the genus. This supports the conclusion reached by others (Wagner & Chen, 1965; Kanamori, 1969).

It is of interest to consider the taxa that had about 35% germination. This level of germination was between the high percentages for the fertile species and the low percentages for the hybrids. The reduced germination for the spores of one plant of *D. celsa* probably was due to an internal factor which influenced the spores

or spore development. It is unlikely that the reduced germination can be explained by environmental conditions because these spores were formed, collected, and grown under the same conditions as spores from other plants of *D. celsa*. The high percentage

TABLE I. SPORE SIZE, STANDARD DEVIATION, AND PERCENT GERMINATION OF VARIOUS DRYOPTERIS TAXA.

Taxa of Dryopteris	*Mean spore length in μ*	*Standard deviation*	*Germination percent*
campyloptera	55.3	± 5.8	79.4
celsa	55.8	± 4.2	78.1
celsa	58.8	± 4.9	90.7
celsa	56.4	± 4.7	85.6
celsa	50.2	± 3.0	37.3
clintoniana	69.8	± 3.1	95.0
clintoniana	69.1	± 4.3	92.3
cristata	59.2	± 2.9	80.2
goldiana	44.0	± 2.4	82.7
intermedia	41.5	± 3.2	88.2
marginalis	44.6	± 3.5	90.9
marginalis	44.8	± 3.5	89.3
campyloptera × intermedia	48.8	±14.8	0.5
celsa × clintoniana	57.9	±19.6	0.5
celsa × goldiana	51.9	±13.6	1.5
celsa × marginalis	55.3	±12.1	34.3
clintoniana × cristata	56.2	±15.0	3.9
clintoniana × cristata	60.2	±10.1	36.0
cristata × intermedia	51.5	±13.2	1.4
cristata × marginalis	52.9	±16.5	8.3
cristata × spinulosa	57.5	±22.5	0.5
filix-mas × marginalis	61.1	±14.8	0.0
goldiana × marginalis	45.7	±12.0	0.5

of spore germination in the hybrids *D. celsa* × *marginalis* and *D. clintoniana* × *cristata* was unexpected because low percentages of germination had been reported for sterile hybrids (Wagner & Chen, 1965). The reason for the high level of spore germination for these two plants is unknown, but possibly it is due to a

greater percentage of pseudomeiotic sporogenesis (Morzenti, 1962) in the sporangia of the plants. It should be noted that another hybrid, *D. cristata* × *marginalis*, also had a relatively high level of germination. Although in *Dryopteris* the percentage of spore germination is generally large for the species and small for the hybrids, the exceptions make spore germination by itself a poor character for suggesting hybrid origin for individual plants.

LITERATURE CITED

BLASDELL, R. F. 1963. A monographic study of the fern genus Cystopteris. Mem. Torrey Bot. Club **21** (4): 1–102.

DEBENEDICTUS, V. M. M. 1969. Apomixis in ferns with special reference to sterile hybrids. Doctoral Dissertation, University of Michigan.

KANAMORI, K. 1969. Studies on the sterility and size variation of spores in some species of Japanese Dryopteris. J. Jap. Bot. **44**: 207–217.

LI, J. C. R. 1964. Statistical inference. Vol. I. Edwards Bros., Ann Arbor, Michigan.

MANTON, I. 1950. Problems of cytology and evolution in the Pteridophyta. Cambridge University Press, Cambridge.

MORZENTI, V. M. 1962. A first report on pseudomeiotic sporogenesis, a type of spore reproduction by which "sterile" ferns produce gametophytes. Amer. Fern J. **52**: 69–78.

———. 1967. Asplenium plenum: a fern which suggests an unusual method of species formation. Amer. J. Bot. **54**: 1061–1068.

WAGNER, W. H., JR. 1966. New data on North American oak ferns, Gymnocarpium. Rhodora **68**: 121–138.

———, and K. L. CHEN. 1965. Abortion of spores and sporangia as a tool in the detection of Dryopteris hybrids. Amer. Fern. J. **55**: 9–29.

———, F. S. WAGNER and D. J. HAGENAH. 1969. The log fern (Dryopteris celsa) and its hybrids in Michigan—A preliminary report. Mich. Bot. **8**: 137–145.

WEINBERG, E. S. and B. R. VOELLER. 1969. External factors inducing germination of fern spores. Amer. Fern J. **59**: 153–167.

WHITTIER, D. P. 1965. Obligate apogamy in Cheilanthes tomentosa and C. alabamensis. Bot. Gaz. **126**: 257–281.

———. 1970. The rate of gametophytic maturation in sexual and apogamous species of ferns. Phytomorphology **20**: 30–35.

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The Gametophytes of Natural Hybrids in the Fern Genus Pellaea

THOMAS R. PRAY

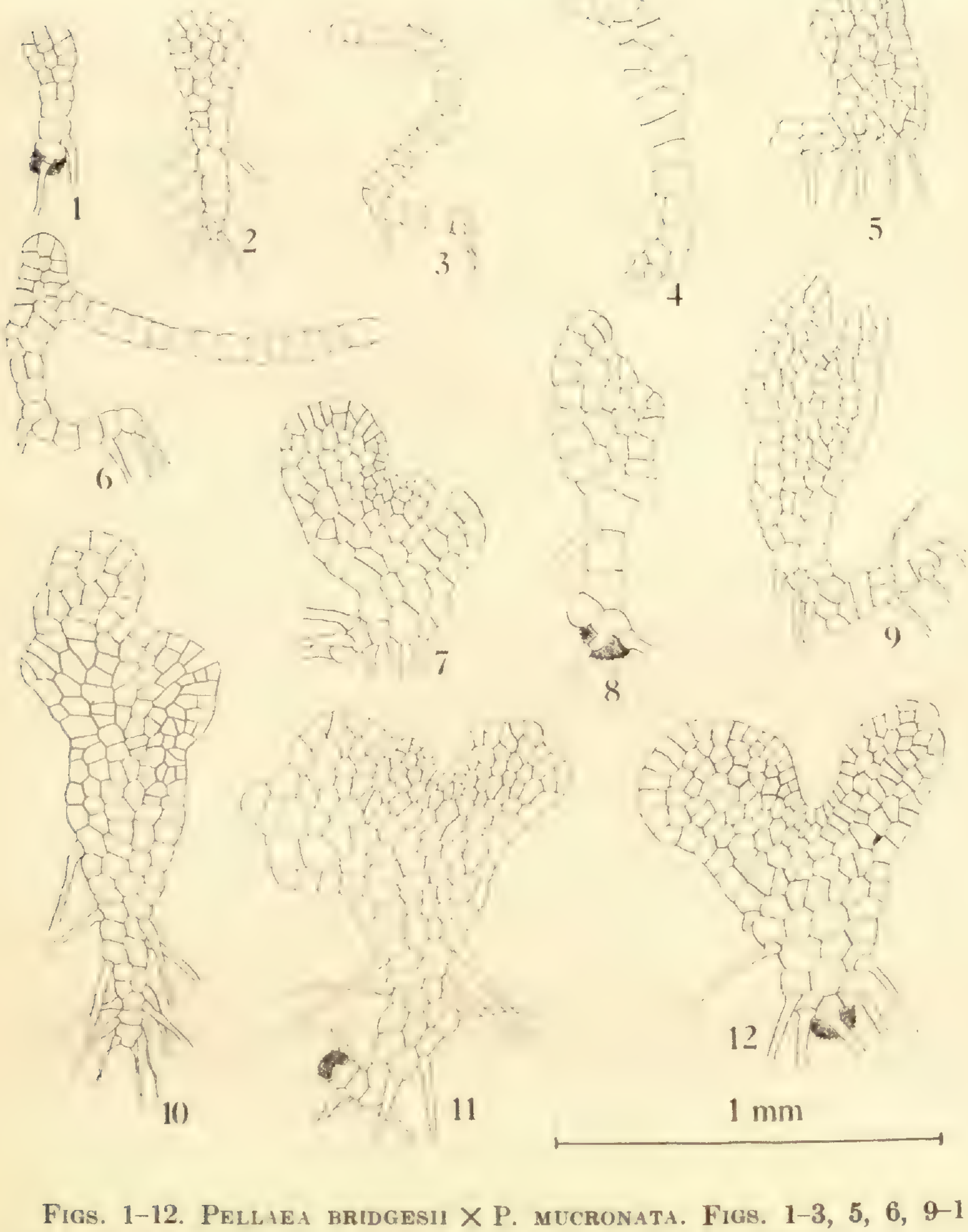
In the course of extensive field work relative to an investigation of *Pellaea* (Pray, 1968a, b, 1970) a number of collections were made on the western slopes of the Sierra Nevada in California of an undescribed member of the genus. Analysis of the plant suggests that apparently it is a hybrid (which will be described in detail elsewhere) of *P. bridgesii* and *P. mucronata*. The various features of the plant are mostly intermediate between those of the morphologically dissimilar parental species. As is to be expected in such a wide cross, the sporophyte is essentially sterile. At times, however, occasional individuals can be found to yield a few viable spores among the far more numerous nonfunctional products of abortive sporogenesis. Among the many individuals examined, two plants from a locality near Yosemite (*Pray 1958, 1961*) had sufficient functional sporangia to give a few spores to be sown on agar. In these sporangia, spore size was variable, with a few obviously larger than the rest. It was apparently the larger spores that were capable of germination. Accurate spore number per sporangium was not determined. It was, however, less than the normal 64.

Spores were sown on nutrient agar as in previous investigations (Pray, 1968a). Most of the larger gametophytes were transferred to sterile soil 2 months after sowing to complete their development. The account which follows is necessarily incomplete due to the small number of gametophytes available. In order to determine whether the gametophytes could reach maturity and reproduce, most were allowed to continue growing, rather than be sacrificed for detailed microscopic examination. The usual complete developmental sequences were therefore not fully realized. Spores from the two hybrid plants used were sown separately. No differences were noted between the progenies, however; they are, therefore, described together.

RESULTS

The outstanding feature of the gametophytes from the hybrid plants was their extreme variability. None of these variations can be attributed to crowding or other unfavorable growth conditions. The germinating spore produces a filament as in other Pellaeas (Pray, 1968a, b, 1970). The filament may then give rise to a regular spathulate plate phase (*Figs. 1, 2*) which lacks a true apical cell. A few thalli (*Fig. 2*) may show a terminal cell with the appearance of an apical initial. Such a cell does not function as a true initial, however. Growth is generally diffuse at this phase. As the plate expands a marginal meristem with multiple initials is differentiated. This may occur in a terminal position. If so, the meristem soon occupies a shallow sinus and a typical cordate thallus with more or less equal wings is the result (*Fig. 12*). Although this form of thallus, derived from the most regular of the young plates, was observed in both groups of gametophytes, it is found in 1% or less of the total number of thalli. Sometimes a somewhat lateral meristem will differentiate (*Figs. 5, 7*). Strictly lateral meristems were also observed (*Fig. 10*). It is assumed that these latter types will eventually give rise to cordate thalli through the formation of a second wing and unequal growth rates of the regions lateral to the meristem. Thus the meristem is shifted to a terminal position. Asymmetrical thalli such as *Fig. 11* are usually the derivatives of those with at least slightly lateral meristems at an earlier stage.

Except for those relatively few gametophytes which followed fairly standard pathways of development for *Pellaea*, the remainder were quite aberrant. These usually lacked, or tended to lose, recognizable centers of growth. Frequently the shift from filamentous to two-dimensional growth failed to occur or was considerably delayed (*Figs. 3, 4*). This inability to initiate organized two-dimensional growth could be permanent with the result that the filamentous phase continued to spectacular lengths. *Figure 15* shows the major portion of a 2-month old gametophyte 4 mm long. This individual has remained entirely uniseriate except for the vertical wall near the base. Some of its more regular con-



Figs. 1–12. Pellaea bridgesii × P. mucronata. Figs. 1–3, 5, 6, 9–11 from Pray 1861 (USC). Figs. 4, 7, 8, 12 from Pray 1858 (USC).

temporaries were typical cordate forms up to 4–5 mm in width. Sometimes the filamentous phase did eventually evolve non-terminal 2-dimensional regions (*Fig. 4*) which could differentiate a more normal appearing plate (*Fig. 6*). In this instance a meristem might finally appear although such was not actually observed. *Figure 6* might be interpreted as a case in which the filamentous portion is a secondary outgrowth and not the original terminal portion of the thallus. The precise developmental histories of extremely peculiar, ameristic forms (*Figs. 16, 17*) is also uncertain. It is possible that these have arisen through localized expansion of median or basal areas of extended filaments. On the other hand. fairly regular early plate phases may have failed to differentiate meristems and developed filamentous outgrowths subsequently. It is worth noting that *Figs. 4, 15–17*, show much greater cell size than their counterparts. This suggests that continued cell enlargement has occurred in the absence of normal rates of cell division. It is also possible, of course, that as a result of meiotic irregularities these particular thalli have higher chromosome numbers.

Between the extremes represented by the above examples, there were intermediates of all sorts. *Figure 8*, with its large cell size, suggests a relationship to *Fig. 4*. Or perhaps this figure represents a form which has had more regular development and will ultimately organize a lateral meristem. Likewise, *Fig. 9*, which lacks a meristem as yet, may be on the pathway to more normal growth or is becoming ameristic.

From the original group of gametophytes, a very few grew on to become mature, normal-appearing thalli. These few were generally those whose development was most nearly normal. Thus among the survivors, a cordate thallus was sometimes encountered (*Fig. 13*). These tended to retain a rather shallow sinus. At the other extreme of variation were highly irregular, lobed forms (*Fig. 14*). The remainder were intermediate. Both types of gametangia were produced and, at about one year, a few sporophytes appeared. These were apparently the products of fertilization by functional gametes. Several sporophytes survived for some time. They were rather similar to one another and more closely re-

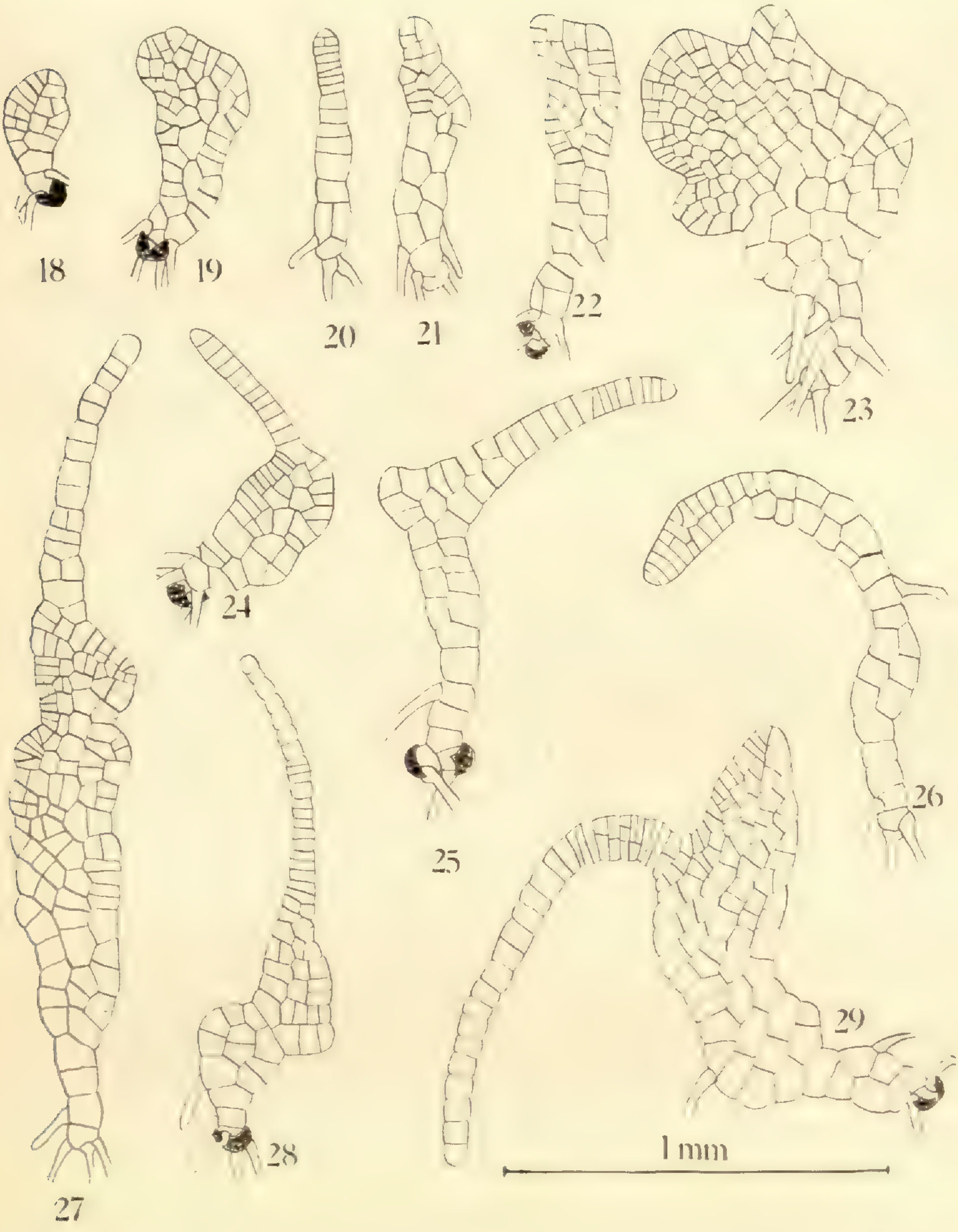
Figs. 13–17. Pellaea bridgesii × P. mucronata. Figs. 13, 15 from Pray 1858. (USC). Figs. 14, 16, 17 from Pray 1861 (USC). Fig. 14 is a thallus with antheridia.

sembled the hybrid plants than they did either parental species. This lack of variability suggests apogamy. No evidence of asexual buds was noted however. All of the young sporophytes were eventually lost while they were still immature.

DISCUSSION

It might be expected that in view of the intermediate nature of the hybrid sporophyte that the gametophytic generation would also show a compromise of the differences between the probable parents. The gametophytes of the parental species are markedly distinct in developmental features (Pray, 1968a). While the mature thallus of both species is cordate, the younger stages are distinguishable. In *P. mucronata* there is the regular differentiation of a strongly lateral meristem which only gradually becomes shifted to a terminal and eventually median position on the maturing thallus. In *P. bridgesii*, on the other hand, the marginal meristem is terminal from the beginning or at most only slightly asymmetrically situated; no truly lateral meristems occur. Thus it is the original site of the meristem which most obviously distinguishes the gametophytes of the two species. In the hybrid, however, the great majority of the thalli never differentiate a meristem of any kind. Of those few which do, some are similar to one parent, some more like the other. This situation may indeed be a compromise between the parental pathways of development. It is of interest to note that certain *Pellaea* species, such as *P. ternifolia*, are also characterized by just such variability in the site of meristem differentiation (Pray, 1968a). On the other hand, the filamentous or ameristic thalli are unlike anything shown by either parent.

There is also the question as to what extent the data from this particular hybrid are typical of nearly sterile fern hybrids. On this point, some observations on an other example are pertinent. A specimen was collected by the author in Arizona which appeared to be *P. longimucronata* (*Pray 3218*). More careful examination suggests that the plant is actually the hybrid of *P. longimucronata* and *P. wrightiana*. The specimen showed a high degree of sporangial



Figs. 18–29. Pellaea longimucronata × P. wrightiana from Pray 3218 (USC).

abortion but did have a few apparently good spores. When the spores were sown on agar, a few gametophytes did develop which exhibited the same variability and high frequency of aberrant types (*Figs. 18–29*) as described here for the California plants. A few thalli (*Figs. 18, 19, 23*) had developmental sequences much like that of the parental species (Pray, 1968a). Filamentous (*Figs. 20, 25, 26*) and highly variable elongated forms (*Figs. 21, 22, 24, 27–29*) were also present. The great majority of thalli were thus quite different from what might be expected. The most obvious effect of hybridity was the extension of the filamentous phase and the inability to initiate normal two dimensional growth and marginal meristems. It would appear then that the preceeding account does not constitute an isolated instance, but rather that similar aberrant growth patterns are to be expected from the gametophytes of hybrids of this type.

It may be significant that previous examples of gametophytes which closely resemble those of these nearly sterile hybrids have been recorded for certain apogamous ferns. Thus the thalli of some apogamous samples of *P. andromedaefolia* (Pray, 1968b) closely match the more peculiar forms of the hybrids described above. Other apogamous Pellaeas (Pray, 1970) may also have similar forms. On the other hand, that apogamy is not necessarily associated with aberrant gametophytic development is also clear. Again, in the case of *P. andromedaefolia* one apogamous population had quite regular gametophytes. Such exceptions were also noted in some other asexual Pellaeas, *P. atropurpurea* for example (Pray, 1968a). In view of the resemblances between the hybrid gametophytes and those of many apogams, it is noteworthy that apogamy is often associated with taxa or "races" which have arisen through hybridization (Tryon, 1968). The difference is, of course, that these latter have become stabilized and self-perpetuating through apogamy, whereas the hybrids described in this paper apparently have not done so (as yet?).

Finally, one might wonder whether the variations and irregularities of development in the gametophyte generation of these hybrid ferns have the same basis as, or are analogous to, what Wagner

(1962) has discussed in the case of the sporophytic features of hybrid ferns. For the hybrids described by Wagner there was frequent asymmetry and irregularity of various leaf characteristics by which the parental species differed. Particularly pertinent here was the conclusion that "hybrid expression is not a uniform and regular compromise." While this statement also applies to the situation described in this paper for gametophytes, the causes may not be the same. In the sporophytes full genomes from the parental species are present and interacting. In the spores which produce the hybrid gametophytes such is probably not the case. Without a thorough investigation of sporogenesis and chromosomal assortment in the hybrids, the chromosomal complements present in the various gametophytes remains unknown. It is, in fact, likely that they are variable chromosomally unless the functional spores are all the result of a non-reductional process. Chromosomal variability might explain the extreme variability of the gametophytes.

LITERATURE CITED

PRAY, T. R. 1968a. The gametophytes of Pellaea section Pellaea: Dark-stiped series. Phytomorphology **18**: 113–143.

———. 1968b. Interpopulational variation in the gametophytes of Pellaea andromedaefolia. Amer. J. Bot. **55**: 951–960.

———. 1970. The gametophytes of Pellaea section Pellaea: Light-stiped series. Phytomorphology **20**: 137–144.

TRYON, A. F. 1968. Comparison of sexual and apogamous races in the fern genus Pellaea. Rhodora **70**: 1–24.

WAGNER, W. H., JR. 1962. Irregular morphological development in hybrid ferns. Phytomorphology **12**: 87–100.

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Schemochromic Blue Leaf-surfaces of Selaginella

DENIS L. FOX[1] AND JAMES R. WELLS

Schemochromic (i.e., optical or structural, non-pigmentary) colors are common in many animals, e.g., (1) Tyndall-blue scattering in the iris of blue eyes; in skin areas of some birds, fishes, reptiles, and primates; in many feathers, as in jays; and (2) interference-produced iridescence in pearl, nacre, wing-covers of some beetles, wing-scales of *Morpho* and many other butterflies, in feathers of peafowl, nummingbirds, pigeons, and other birds (Fox, 1953).

Although plants excel animals in the numbers and chemical varieties of true biochromes (colored molecules or pigments) that they store, instances of schemochromic coloration exhibited by plants are very rare. Moreover, the few examples involve no Tyndall-blue scattering, but are limited to the display of changeable spectral interference-colors, notably by a few seaweed species such as *Iridophycus*, *Chondria*, *Zonaria*, and others as viewed immersed in sea-water. A few exceptions found among land plants include some *Lycopodium* species[2] and certain *Selaginella* species, e.g., *S. willdenovii* (Desv.) Paker, a native of Malaysia.[3] The latter species has been introduced elsewhere, and is maintained in greenhouses, including the University of Michigan's Matthaei Botanical Garden, where the specimens studied were obtained through the kindness of Professor W. H. Wagner, Jr.

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[1] Distinguished Scholar, Cranbrook Institute of Science, 1970–1971; permanent address: Division of Marine Biology, Scripps Institution of Oceanography, University of California, San Diego; La Jolla, CA 92037. I thank Dr. Warren L. Wittry, Director, and his colleagues at the Institute, for the honor and the many courtesies extended during a year's appointment there.

[2] C. V. Morton and I. L. Wiggins have reported independently to us their observations of surface-iridescence on pinnae of some species of true ferns.

[3] There are also a few true ferns that exhibit iridescence on the adaxial surfaces, such as *Anemia makrinii* Maxon; however, in this species at least this disappears after drying.—C.V.M.

The upper surfaces of this plant's leaflets exhibit, by sunlight or diffuse light, striking, changeable blue colors, reminiscent of the wings of *Morpho* butterflies but less brilliant. Microscopic inspection by reflected light, under medium powers, reveals countless microspheric raised areoles, like masses of very minute beads, highlighted on the upper, projecting surfaces and exhibiting successive blue, blue-green, and purple or violet hues, depending on the increasing angle of vision. When viewed at a fairly acute angle, the leaf's optical effects vanish, the surfaces then exhibit merely the green color of chlorophyll.

It has been somewhat surprising not to encounter more published references to these striking changeable chromatic features over the upper leaflet surfaces of *Selaginella*. Walton and Alston (1938) commented upon the "metallic sheen of their leaves . . . due to the presence of particles in the cutin of the epidermis which reflect certain rays of light."

While those authors came close to the factual basis of the observed coloration, the reference to "particles" was perhaps misleading, connoting as it does the presence of substantial, persistent material, perhaps of a solid character. The microsurfaces which reflect a changeable spectrum of optical colors are in fact air which is distributed into a pattern of minute films; hence the air is not discharged, nor the color quenched, by squeezing or rubbing a leaflet between the fingers.

The optical colors disappear when the leaves are allowed to wilt. They are discharged also on wetting the fresh leaves briefly with either water or ethanol, but on evaporation or blotting of the fluid, the colors are restored. However, if a wetting agent, e.g., the clearing fluid Aerosol (Eimer and Amend) is applied, the immediate quenching of the bright colors is permanent, even after the treated specimen is rinsed in water and superficially dried.

Examination by transmitted light under high optical powers (400 ×) reveals stomates over the abaxial leaf-surfaces and many small, light-refracting, air-filled spaces on the adaxial surfaces. The individual dark, light-refracting elements become suddenly clear as water gradually fills the air-spaces.

The exposed cuticular layer of air-laden micro-spaces between the regular, projecting elements of the bead-like clusters, thus reminiscent of very minute interstitial soap-films, is the seat of the iridescent color-production. In much the same manner, entrapped microfilms of air give rise to the striking changeable blue colors of *Morpho* wings, which likewise are instantly quenched by the addition of foreign fluids having the same refractive index as the solid wing-protein, and which are restored on leaching away the fluid or allowing it to evaporate (Fox, 1953).

Whether this unusual chromogenic manner of storing air on the upper surfaces of the leaflets may be merely an incidental condition, evoked by photosynthetic, respirational and transpirational processes, and may be of no selective advantage to the plant, or whether it may in fact serve a role of physiological or biophysical importance (e.g., such as thermal buffering, light-screening, or water-retaining functions) must remain a problem for plant physiologists.

LITERATURE CITED

FOX, D. L. 1953. Animal Biochromes and Structural Colours. Cambridge University Press.

WALTON, J., JR., and A. H. G. ALSTON. 1938. Chapter XVII: Lycopodiinae. *In* Fr. Verdoorn, ed. "Manual of Pteridology." Martinus Nijhoff, The Hague.

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Shorter Notes

ASPLENIUM KAMTCHATKANUM GILBERT, A DUBIOUS EASTERN ASIATIC FERN.—In the "Index Filicum" of 1905, *Asplenium kamtchatkanum* Gilbert (Fern Bull. **9**: 54. 1901) is listed as dubious, with the comment "*Athyrium* sp.?" Apparently no one has ever examined the type, which is right here in the U. S. National Museum. It was collected on the U. S. North Pacific Exploring Expedition on the Ochotsk Sea, Kamtchatka, by J. Small, between 1853 and 1856, and had been originally identified as *Asplenium filix-femina* L. The same species was collected also by the same expedition on Yezo Island.

This species was overlooked in Komarov's "Flora of Kamtchatka" (1927), and in Hultén's "Flora of Kamtchatka and Adjacent Islands" (1930) it is mentioned only as an unknown species of doubtful position. The type shows that this plant is the same as *Athyrium pterorachis* Christ, a species reported in Ohwi's "Flora of Japan" from Hokkaido, Honshu, Sakhalin, southern Kurile Islands, and Kamtchatka. It is a rather distinctive species, especially in the pubescent costae beneath, and clearly has nothing to do with *Athyrium filix-femina*. In fact, this species and some others have in recent years been removed entirely from *Athyrium* and placed in *Dryoathyrium*, *Lunathyrium*, or *Parathyrium*. If one assumes that the rachis structure is of fundamental importance in this group of ferns, then indeed this species and its allies will have to be separated from *Athyrium*, which differs in having the rhachis groove above interrupted and open to receive the grooves of the lateral pinnae. The matter has been discussed most recently by Hideaki Ohba in his paper "Considerations on the Genus Lunathyrium of Japan" (Sci. Rep. Yokosuka City Mus. **11**: 48–55. 1965). He recognizes the single genus *Lunathyrium* Koidz. (1932) with three sections—sect. *Lunathyrium*, sect. *Athyriopsis* (*Athyriopsis* Ching, Acta Phytotax. Sinica **9**: 63. 1964; Type: *L. japonicum*), and sect. *Dryoathyrium* (*Dryoathyrium* Ching, Bull. Fan Mem. Inst. Biol. Bot. **11**: 79. 1941; Type: *L. boryanum*; a synonym is *Parathyrium* Holttum, 1958). This seems the most

reasonable treatment. The essential synonymy is as follows:

LUNATHYRIUM PTERORACHIS (Christ) Kurata in Namegata & Kurata, Enum. Jap. Pterid. 309. 1961. [reprint without change of paging from "Collection and Cultivation of Our Ferns and Fern Allies" by T. Namegata].

Athyrium pterorachis Christ, Bull. Herb. Boiss. **4**: 668. 1896.

Asplenium kamtchatkanum Gilbert, Fern Bull. **9**: 54. 1901.

Asplenium kamtchaticum Hultén, Kungl. Sv. Vet. Akad. Handl. **8**(2): 237. 1930. Unintentional and illegitimate renaming of *A. kamtchatkanum* Gilbert.

Dryoathyrium pterorachis Ching, Bull. Fan Mem. Inst. Biol. Bot. **11**: 81. 1941 (as "*pterachis*" erroneously).

Parathyrium pterorachis Holttum, Kew Bull. **1958**: 449. 1959.

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A NEW LOCALITY FOR PSILOTUM NUDUM IN SONORA, MEXICO—In the spring of 1970, while studying the palm oases on the central coast of western Sonora, Mexico, I discovered a small colony of *Psilotum nudum* Palisot in Nacapule Canyon in the mountains near San Carlos Bay and about 10 miles northwest of Guaymas. The mouth of this canyon is located about 4.5 miles in from the coast, and the narrow canyon drains to the east out of steep and rugged volcanic mountains. The *Psilotum* grew at an alga-covered seep on the canyon wall in the shade of palms, *Washingtonia robusta* Wendl., and a few trees of a fig, *Ficus padifolia* H.B.K. While this locality is definitely in the Sonoran Desert, the shade of the canyon and the constant water supply provided by springs and seeps allows a number of plants with high water requirements to survive. Only one colony of *Psilotum* with about a dozen stems two to three inches high was found. A small collection of this plant (*Boutin & Brandt 2814*) is now growing in the Huntington Botanical Gardens.

Besides the Nacapule Canyon locality, three other stations are known for *P. nudum* in southern Arizona, Sonora, and western

Chihuahua. It was recently reported in Sycamore Canyon, Arizona by Phillips (Amer. Fern J. **60**: 30–32. 1970). It is also known in the Sierra Saguaribo of eastern Sonora in the drainage of the Río Mayo, as reported by Gentry (Rio Mayo Plants, 1942), and from the Barranca del Cobre of Chihuahua, reported by Knobloch and Correll (Ferns and Fern Allies of Chihuahua, 1962) and also recently collected by Kimnach and Brandt (*980*). The habitat of Knobloch's collection was not reported; however, each of the other collections has been recorded as being from a rock crevice or cliff site.—FREDRICK C. BOUTIN, *Huntington Botanical Gardens, San Marino, CA 91108.*

Recent Fern Literature

THE CLASSIFICATION OF THE CYATHEACEAE, by R. M. Tryon, Jr. Contr. Gray Herb. **200**: 4–53. 1970.—The scaly Cyatheaceae have mostly been divided into three traditional genera—*Cyathea*, with a complete indusium, *Hemitelia*, with a lateral, semispherical indusium, and *Alsophila*, with the indusium reduced to a small scale or absent. It has seemed to many that these three genera, although admittedly rather artificial, do represent natural groups, at least so far as the American species are concerned, for it has seemed that the species were more closely related to others in their own group than to those of other groups. However, Copeland, followed by Domin, did not agree and lumped all the species in a single large genus, without any subgeneric classification or other grouping. Recently, Holttum, working on Old World species, established a new classification in which the scale characters were regarded as more important than the indusial characters. Tryon has followed Holttum by working on the New World species, and has developed a new system. He divides *Cyathea* into six genera—*Sphaeropteris*, *Alsophila*, *Nephelea*, *Trichipteris*, *Cyathea*, and *Cnemidaria*. *Sphaeropteris*, mostly Old World, contains those species with the cells of the petiolar scales all alike. The other genera have the marginal cells variously differentiated. *Alsophila* and *Nephelea* have the petiolar scales with a dark apical seta, and

sometimes also such setae on the back or margins. *Alsophila*, also mostly Old World, has no spines or, if these are present, they are not "corticinate". *Nephelea*, strictly New World, has "squaminate" spines, the smaller ones being thin-marginate and scalelike. *Cnemidaria*, *Cyathea*, and *Trichipteris* have the petiolar scales lacking setae. In *Cnemidaria*, strictly American, the veins are areolate or, if free, the basal veins on each side are connivent to the sinus. *Cyathea* and *Trichipteris* have the veins all free and reaching the margin above the sinus. *Trichipteris*,[1] strictly American, includes most of the exindusiate species that have been called *Alsophila*. *Cyathea*, also strictly American as here delimited, includes the indusiate species. In addition to the genera mentioned above, the generally recognized genera *Lophosoria* and *Metaxya* are treated.

Tryon believes his classification to be natural. It may be so, although it does have the appearance of being a "one-character" classification, the scale character being the decisive one in placing a species into a genus. It will certainly be useful in identifying specimens, and the stressing of the petiolar scale characters may influence collectors to be more careful to collect full specimens rather than detached pinnae. Tryon has not really justified his recognization of these groups as independent genera, his only statement being that he believes each genus to be a major evolutionary line, but that could and should be equally true also of subgenera. However that may be, Tryon is to be congratulated on a major contribution to the taxonomy of the Cyatheaceae. He is likely to be widely followed.—C.V.M.

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[1] It is unfortunate that Tryon adopts the spelling "*Trichipteris*." He states that the original spelling must stand. This is not true by the Code. Recommendation 73G, d, indicates that the proper connecting vowel in Greek in cases like this is an "o." Although this is only a recommendation, it is also made into a Rule by Art. 73, Note 2, which states that a wrong connecting vowel is treated as an orthographic error; the "Notes" in each article are an integral part of the Rules, put in to explain the operation of the Rule itself. The main body of Art. 73 indicates that orthographic errors are to be corrected. Therefore, the correct name *must* be *Trichopteris*. Since this is merely a correction rather than a different name it will continue to be credited to Presl in 1822. The matter is exactly like the use of a wrong connecting vowel in specific epithets, which also must be corrected by Art. 73.

A MANUAL OF PLANT NAMES (Second revised edition), by C. Chicheley Plowden. pp. 1–260. 1970. Published by Philosophical Library, 15 East 40 St., New York, N. Y., 10016. $10.00.—This book is intended for the gardener and amateur botanist who is interested in the meaning of plant names. Those treated are primarily plants cultivated for food, drugs, or ornament, and the commoner wild plants. The etymology of the Latin generic and specific names is given, and also a glossary of botanical terms used in descriptive botany. Needless to say, it will not replace a scholarly and indispensible work like R. W. Brown's "Composition of Scientific Words" or B. D. Jackson's "A Glossary of Botanic Terms," but it may find a place by those interested in less technical and less complete works. I would not myself completely trust the etymologies given (although I must confess that I have not checked many of them). For instance, *Glechoma* is said to be derived from "glaukos" (gray), but it is surely from "Glechon," the Greek name of some kind of pennyroyal. *Pteris* is said to be from "pteron, a wing," but it is actually merely the Greek word pteris, applied to a fern; pteris *may* have come originally from "pteron," which means primarily "feather" rather than "wing." *Fragaria* is not derived from "fragrans" but is a Linnaean variant of "fraga," the Roman name for the strawberry; it may have ultimately been derived from "fragrans" by the Romans. But no matter, the derivations are suggestive and doubtless correct in most instances.—C. V. M.

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DAVID B. LELLINGER

C. V. MORTON ROLLA M. TRYON

IRA L. WIGGINS

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American Fern Journal

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American Fern Journal

VOL. 61 OCTOBER–DECEMBER, 1971 NO. 4

The Genus Grammatosorus

C. V. MORTON

The almost unknown species *Grammatosorus blumeanus* Regel was published in the "Index Seminum" of the botanical garden in St. Petersburg in 1866; it was based on a cultivated plant that Regel had received from a man named Booth under the unpublished name of "*Aspidium blumei.*" This Booth was probably John Booth, of Flottbeck, who according to the "Index Herbariorum Index of Collectors" collected in Java. Regel indicated that the original habitat was probably the East Indies. The connection with Blume is obscure.

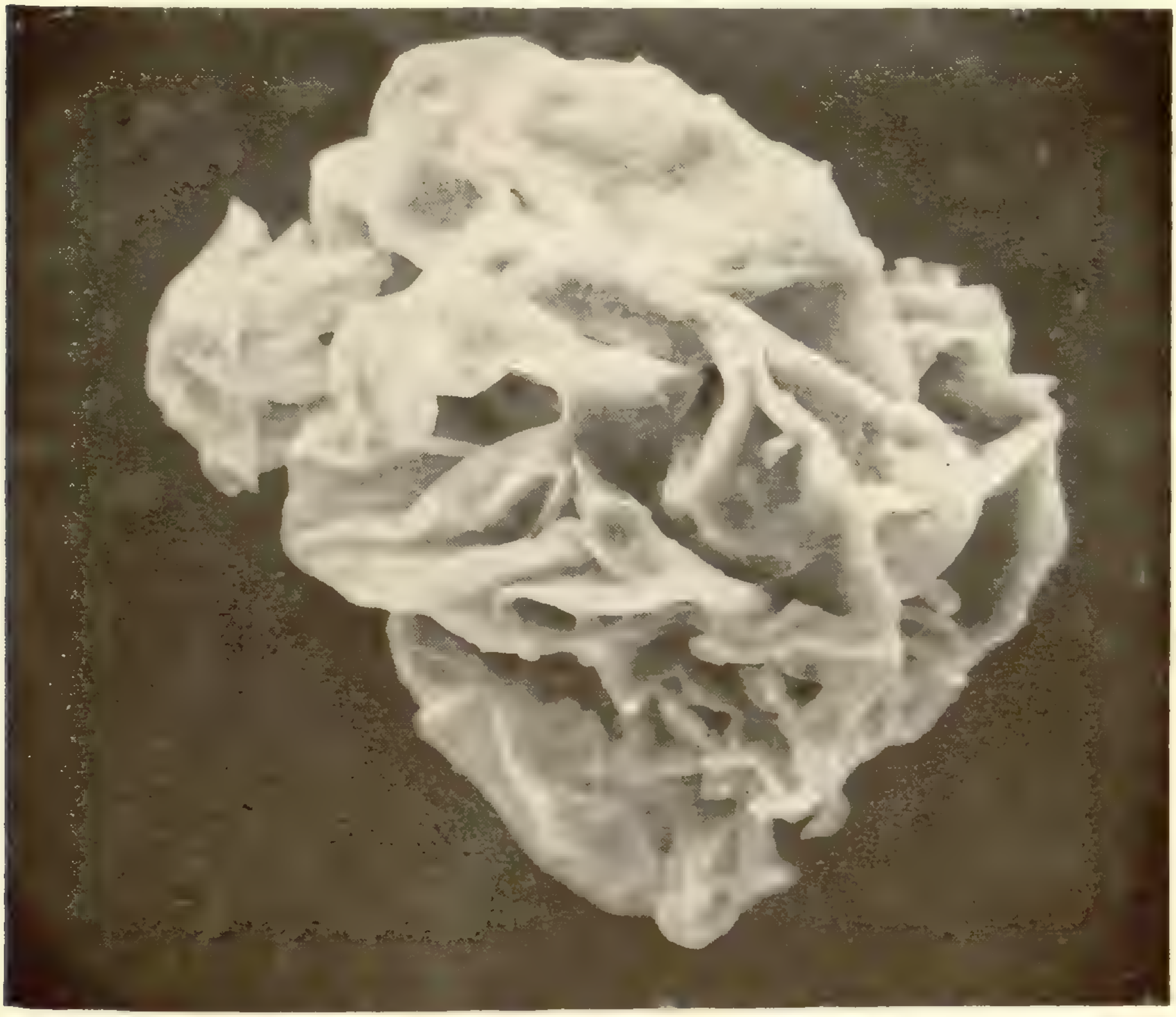
J. Milde obtained a specimen from Regel and studied it carefully, and published his results in the "Botanische Zeitung" (26: 614–617. 1868). He concluded that the plant might represent either a sport developing in cultivation or a hybrid.

This plant has remained essentially unknown for the last hundred years. It disappeared rapidly from cultivation, and no wild specimens resembling it have been discovered. Through the courtesy of the Director, Botanical Institute of the Academy of Sciences of the U.S.S.R. in Leningrad, I have been permitted to have the type on loan; a photograph of it is given herewith. It is a rather poor specimen, lacking a rhizome, The habit and venation are those of *Tectaria*. The general irregularity in cutting makes it appear that this may indeed be a hybrid, and this is partly confirmed by the fact that most of the sporangia are abortive. A photograph of one of the larger and better developed spores made by the scanning electron microscope is shown in the accompanying figure, but even this is not a fully developed and regular spore.

Volume 61, Number 3, of the JOURNAL, pp. 97–144, was issued Nov. 15, 1971.

Holotype sheet of Grammatosorus blumeanus Regel (LE)

The chief peculiarity of *Grammatosorus* that caused Regel to describe this as a new genus is the sorus, which is strongly elongate along the reticulate veinlets; it is obviously indusiate throughout. Elongate, indusiate sori such as might occur in *Diplazium* are



SCANNING ELECTRON MICROSCOPE PHOTOGRAPH OF GRAMMATOSORUS BLUMEANUS, × 570.

not characteristic of *Tectaria*. There is however one species in which such sori occur, namely the extremely peculiar *Tectaria dolichosora* Copeland (Phil. J. Sci. **38:** 136. 1929); in this the sori are strongly elongate and indusiate; they curve around at the tip, thus becoming athyrioid in shape, and come back down the outer side of the veinlet, sometimes clear to the bottom, thus

making a truly diplazioid, double sorus, with the indusia back to back and the sporangia spreading in both directions. In *Grammatosorus* the sori do sometimes curve a little at the apex where there is a vein fork, but they do not come back on the other side to form a diplazioid sorus. Other than in the sori there is no obvious alliance between *Grammatosorus* and *T. dolichosora*. In the latter the blade is much more divided and the axes are dark as in *T. melanocaulon* (Blume) Copel.[1] In *Grammatosorus*, the stipe and rhachis are stramineous.

It may indeed be that *Grammatosorus* is a hybrid, in which case one of the parents might be *Tectaria* (*Arcypteris*) *irregularis* (K. B. Presl) Copel.; I would not dare guess as to the other parent, which would probably be in another genus. On the other hand, the existence of another species, *T. dolichosora*, with somewhat similar soriation indicates that this plant might well be a true *Tectaria*, for there is no evident reason to think that *T. dolichosora* is also a hybrid. In order to provide this plant with a nomenclaturally correct name, the following new combination is proposed:

TECTARIA **blumeana** (Regel) Morton, comb. nov.

Grammatosorus blumeanus Regel, Ind. Sem. Hort. Petrop. **1866: 75. 1866.**

Aspidium grammatosorus Salom. Nom. **54. 1883.** A superfluous and illegitimate name, since Salomon ought to have adopted the epithet *blumeanum*, which was available. Doubtless he did not because of the existence of an *Aspidium blumei* Kunze ex Mett. (1856), an entirely different plant. However, according to the Code both *blumei* and *blumeanum* are possible and correct, since thay are considered different names.

NATIONAL MUSEUM OF NATURAL HISTORY, WASHINGTON, DC 20560.

[1] This name is wrongly spelled "*melanocaulis*" by Copeland, apparently to make it feminine to agree with *Tectaria*. However, the original *melanocaulon* of Blume is a substantive and therefore invariable.

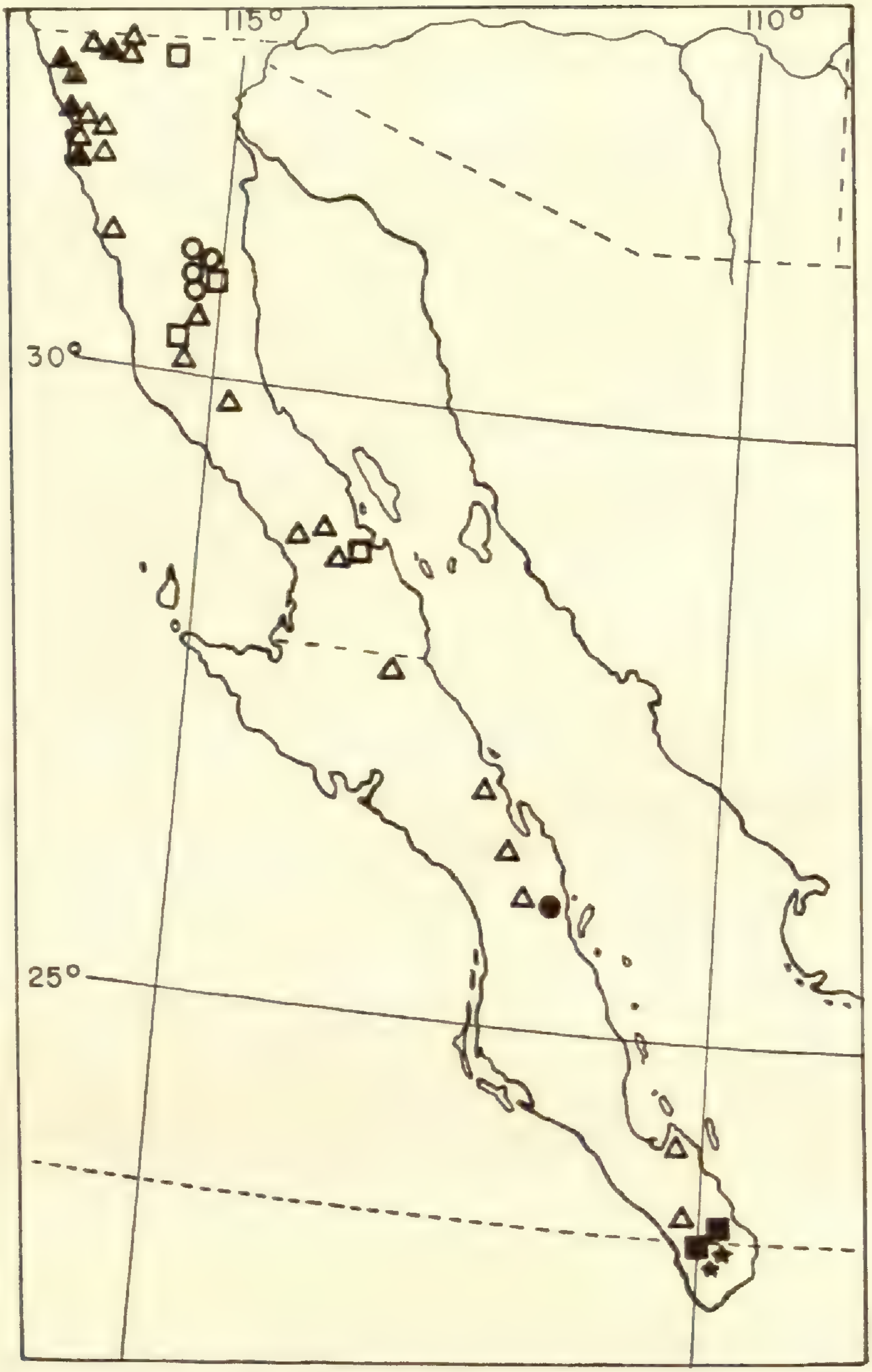
The Genus Selaginella in Baja California, Mexico

IRA L. WIGGINS

The genus *Selaginella* was omitted from the "Vegetation and Flora of the Sonoran Desert" (Shreve and Wiggins, 1964) because all material available to me at the time had been collected at altitudes above the elevation we had accepted as marking the upper limit of the Sonoran Desert, or came from areas in the Upper Sonoran Zone in northwestern Baja California. But when one considers the entire peninsula of Baja California, it contains seven species of Spike-moss, five of which Tryon places in the subgenus *Selaginella* section *Tetragonostachys* (A. Braun) Hieron. (Ann. Mo. Bot. Gard. **42**: 1–99. 1955). The other two belong in the subgenus *Stachygynandrum* series *Circinatae*, according to Alston (in Verdoorn, "Manual of Pteridology," pp. 503–4. 1938). These seven Spike-mosses may be distinguished with the aid of the following key, and are illustrated here by line drawings in *Plate 23 et seq.* The drawings are offered as supplements to the excellent half-tone reproductions in Tryon's paper in order to emphasize certain details.

KEY TO THE SPECIES OF SELAGINELLA IN BAJA CALIFORNIA

1. Stems (with attached leaves) terete or quadrangular, not dorsiventrally flattened; plants erect, ascending, or decumbent but not forming rosettes, not rolling into a ball when dry; leaves narrowly lanceolate to linear-lanceolate, with a median longitudinal groove on abaxial side (Subg. *Selaginella*).
   2. Stems erect or ascending, not decumbent or prostrate; rhizophores produced only at or near bases of main stems (Ser. *Arenicolae*).
      3. *S. bigelovii*
   2. Stems creeping or prostrate, the main ones neither erect nor strongly ascending; rhizophores along lower side of most of stem.
      3. Setae at apex of vegetative leaves and sporophylls denticulate scabrous; leaves markedly glaucous; sporophylls acuminate (Ser. *Rupestres*) ..... 2. *S. asprella*
      3. Setae at apex of leaves smooth, filiform and ephemeral, or lacking; leaves bright green or persistently ashy-gray (in *S. cinerascens*), not glaucous.

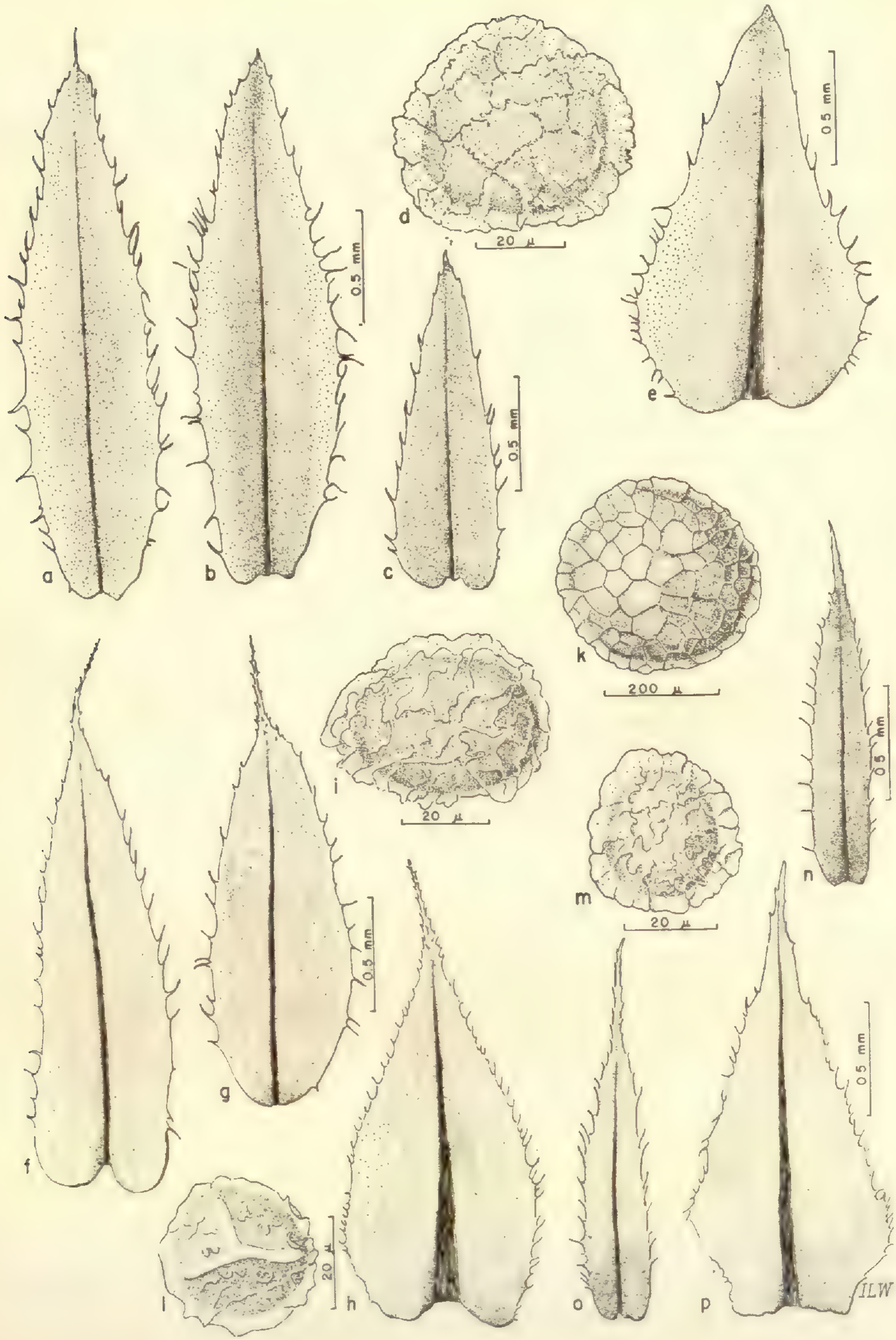


Distribution of Selaginella in Baja California. Solid circle = S. arizonica; Open circle = S. asprella; Open triangle = S. bigelovii; Solid triangle = S. cinerascens; Open square = S. eremophila; Solid square = S. lepidophylla; Solid star = S. pallescens.

4. Ultimate branchlets mostly 2–4 mm long, these and main stems appressed-prostrate; leaves ashy-gray, their tips acute or sometimes muticous, not setiferous; plants growing on soil, not in rock crevices (Ser. *Sartorii*).....4. *S. cinerascens*
4. Ultimate branches mostly 5–12 mm long; tips of branches turned upward, not tightly appressed-prostrate; leaves bright green, not ashy, their tips bearing straight, slender, more or less deciduous setae, or the terminal seta (in *S. eremophila*) filiform and ephemeral, usually visible only on leaves at tips of branchlets (Ser. *Eremophilae*).
    5. Microspores usually orange; terminal seta straight, milk-white, 0.1–0.3 mm long, never equaling leaf blade, often deciduous in age.....1. *S. arizonica*
    5. Microspores usually yellow; terminal seta filamentous, tortuous, often one-half to equaling length of blade, deciduous very early and obvious only on leaves at tips of growing branchlets.....5. *S. eremophila*

1. Stems and branches flattened dorsiventrally; plants prostrate and rosulate when moist, branches curling inward and upward to form a compact ball when dry; leaves dimorphic, those on upper side of stem smaller than ones on lower side, neither series longitudinally grooved (Subg. *Stachygynandrum* Ser. *Circinatae*).
    6. Leaves on lower side of stem suborbicular, rounded at apex, reddish or brownish; leaves on upper side of stem broadly ovate, without a terminal seta, conspicuously white-margined.....6. *S. lepidophylla*
    6. Leaves on lower side of stem ovate, rarely suborbicular, silvery white, acute and short-setiferous at apex; leaves on upper side of stem ovate to orbicular, bearing a stout, terminal, denticulate-scabrous seta, less markedly white-margined.....7. *S. pallescens*

Descriptions published by Maxon (Smiths. Misc. Coll. **72**(5): 1–10, *pls. 1–6*. 1920) and by Weatherby (Amer. Fern J. **33**: 113–119. 1943; J. Arn. Arb. **25**: 407–419, *pls. 1, 2*. 1944) admirably cover the species within the subgenus *Selaginella* that are known to occur in Baja California. Likewise, those in Correll's "Ferns and Fern Allies of Texas," pp. 28–43. 1956, and in Knobloch and Correll's "Ferns and Fern Allies of Chihuahua," pp. 16–32. 1962, deal with some of the species in subgenus *Selaginella* and both of the species in subgenus *Stachygynandrum*. Therefore, I include here only citations of specimens from Baja California examined, together with comments on habitats and distribution.


a
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o
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0.5 mm
20 µ
200 µ
ILW

The line drawings were made with the aid of a Spencer camera lucida and various lens combinations of a Bausch and Lomb compound microscope.

Abbreviations of herbaria from which specimens were studied are those recommended by Lanjouw and Stafleu in "Index Herbariorum," ed. 5, 1964.

1. SELAGINELLA ARIZONICA Maxon, Smiths. Misc. Coll. 72(5): 5, *pl. 3*. 1920.

On rock faces, in crevices in and between boulders and ledges, often on soil or gravel at the bases of boulders, but rarely away from boulders or cliff faces, in Gila, Graham, Maricopa, Pima, and Pinal counties, Arizona, east in southwestern Texas (although not known to occur in New Mexico), south into northern Sonora, and known from a single collection near Loreto, Baja California. Mostly at 600 to 2000 m alt.

SPECIMENS EXAMINED: **Baja California:** Arroyo Undo [Hondo], [near] Loreto, 26 Oct 1930, *M. E. Jones* (DS).

The disjunct distribution of this *Selaginella* is puzzling, for there are areas along the eastern slopes of the Sierra San Pedro Mártir and other ranges in Baja California that would appear to provide suitable habitats for it. More intensive search may reveal it in such areas.

2. SELAGINELLA ASPRELLA Maxon, Smiths. Misc. Coll. 72(5): 6, *pl. 4*. 1920.

On rock faces, in crevices on ledges, at bases of boulders, cliffs, and around talus, Los Angeles, Orange, and San Bernardino

---

FIGS. a–e, SELAGINELLA ARIZONICA: a = FUNCTIONAL LEAF FROM UNDER SIDE OF DECUMBENT STEM, THE TERMINAL SETA INTACT; b = LEAF FROM SAME AREA, SETA DETACHED; c = LEAF FROM UPPER SIDE OF STEM AT SAME LEVEL AS a AND b, TERMINAL SETA DETACHED; d = MATURE MICROSPORE; e = MEGASPOROPHYLL, ABAXIAL SIDE. FIGS. f–i, SELAGINELLA ASPRELLA: f = LEAF FROM UNDER SIDE OF DECUMBENT STEM; g = LEAF FROM UPPER SIDE OF STEM OPPOSITE f; h = MEGASPOROPHYLL, ABAXIAL SURFACE; i = MATURE MICROSPORE. FIGS. k–p, SELAGINELLA BIGELOVII: k = MATURE MEGASPORE, OUTER SURFACE; l = MICROSPORE, COMMISSURAL SIDE; m = MICROSPORE, OUTER SURFACE; n, o = LEAVES FROM SAME LEVEL ON OPPOSITE SIDES OF ASCENDING STEM; p = ABAXIAL VIEW OF MEGASPOROPHYLL.

counties, California, south along the eastern escarpment of the San Jacinto and Cuyamaca Mountains into Baja California.

SPECIMENS EXAMINED: **Baja California:** In crevices of granitic rocks along streams, near La Encantada, Sierra San Pedro Mártir, alt 7800 ft, 22 Sept 1930, *Wiggins & Demaree 5002* (DS); Rocky cliff in first canyon off Cañon del Diablo on NW side of Picacho del Diablo, eastern flank of Sierra San Pedro Mártir, alt 6000 ft, 15 June 1954, *Chambers 643* (DS); Rim overlooking cañon between main range and Picacho del Diablo (Picacho de la Providencia), near Lat. 31° N, Long. 115° 24′ W, about 9000 ft, 5 Sept 1961, *Wiggins 16635* (DS); Crevices in granitic rocks on SE slopes, Cerro Venado Blanco, Sierra San Pedro Mártir, 15 Sept 1968, *Moran 15670* (CAS).

This species is far more common among igneous rocks and cliffs in the Sierra San Pedro Mártir than the small number of specimens in herbaria would indicate.

3. SELAGINELLA BIGELOVII Underw. Bull. Torrey Bot. Club **25:** 130. 1898.

On dry, sunny, rocky slopes and ridges or on soil in partial shade of sparse stands of chaparral, often abundant around boulders or on steeply sloping to nearly vertical cliffs and rock faces, inner Coast Ranges, Santa Clara County, California, southward to the mountains of the Cape Region, Baja California, at elevations between sea level and 1500 feet in the northern part of its range, and upward to over 6000 feet in the Cape Region.

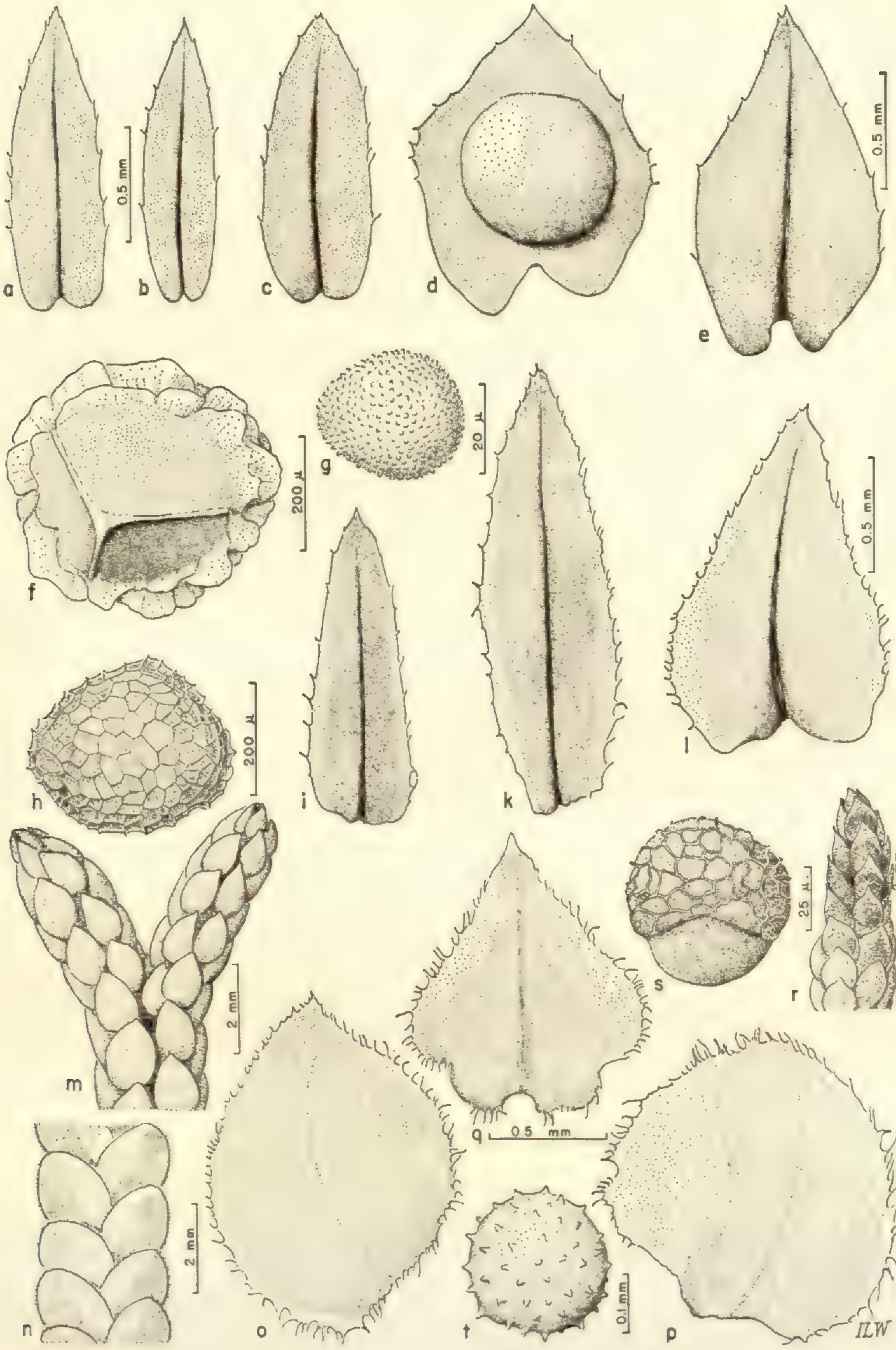
SPECIMENS EXAMINED: **Baja California del Norte:** Brush-covered hills SW of Tijuana on Agua Caliente road, 24 Feb 1934, *R. S. Ferris 8470* (DS); South facing slope about 11.4 mi E of Rodriguez Dam, east of Tijuana, 24 Jan 1966, *Wiggins 20373* (DS); Near Rodriguez Dam, 10 mi E of Tijuana, in tufts at bases of rocks, 1 Apr 1947, *H. F. Copeland* (DS); Hillsides NE of Ensenada, alt 200–400 ft, 23 Feb 1930, *Wiggins 4212* (CAS, DS); About rocks on hillsides facing the sea, Ensenada, 7 Apr 1921, *I. M. Johnston 3005* (CAS); San Carlos River (S of Ensenada), 10 Sept 1923, *Eastwood 12391* (CAS); San Carlos canyon, 10.6 mi E of Ensenada-Santo Tomás road, 8 Apr 1954, *Wiggins 13058* (DS); On dry soil and in crevices in rocks, hillsides above Arroyo de la Agua'Marga, southern Sierra San Pedro Mártir, alt ca 2700 ft, 13 May 1941, *Wiggins 9937* (DS); Slopes of San Antonio Mesa, 11 April 1936, *Epling & Stewart* (DS); About 8 mi E of El Aguajito along road from El Rosario to San Augustín, Lat. 30° 04′ N, Long. 115° 21′ W, alt ca 1500 ft, 6 Feb 1962, *Wiggins & Thomas 68* (DS); About 7 mi S of main San Augustin-Laguna Chapala road, along track to Cerro Blanco and San José, Lat. 29° 42′ N, Long. 114° 25′ W, alt ca 1500 ft, 7 Feb 1962, *Wiggins & Thomas* 120 (DS);

Cataviñá, 14 Apr 1954, *Dorothy R. Harvey* (CAS); North-facing rocky wall of canyon, 2 mi N of Mision de San Borja, 16 May 1959, *I. L. & D. B. Wiggins 14843* (CAS, DS); Rocky ridge above Rancho Aguajito, 32.5 mi SE of El Rosario, 15 May 1956, *Howell 31012* (CAS); Same area, *Porter 162* (CAS); Rocky talus slopes 5 mi W of Mision de San Borja, along road to Rosarito, alt ca 1000 ft, 18 Feb 1962, *I. L. & D. B. Wiggins 16739* (DS); Between boulders in arroyo bottom opposite store at El Arenoso, alt ca 2500 ft, 21 Jan 1960, *Porter 162* (DS); On exposed rocks E slope of Cerro Barranco, Sierra Santa Lucia, near Lat. 26° 56′ N, Long. 112° 28′ W, alt ca 1300 m, 10 Mar 1964, *Moran 11784* (DS); Locally common on north slopes near summit, Cerro San Juan, near Lat. 27° 58′ N, Long. 113° W, alt ca 1200 m, 4 Feb 1964, *Moran 11597* (DS); NW slope, Cerro de la Mina de San Juan, near Lat. 28° 43′ N, Long. 113° 38′ W, 25 Mar 1960, *Moran 8051* (DS). **Territorio Baja California del Sur:** Rocky mountain top, in oak forest, Cerro de la Giganta, alt 5000 ft plus, 1 Mar 1939, *Gentry 4274* (DS); On steep, north-facing slope on ridge NW of main peak of Cerro de la Giganta, alt 1200–1350 m, Lat. 26° 8′ N, Long. 111° 36′ W, 25 Nov 1947, *Carter, Alexander & Kellogg 2050* (DS); Among granite rocks at summit, in *Quercus idonea* with occasional *Q. devia* and *Pinus cembroides*, Sierra de la Laguna E of Todos Santos, alt ca 2000 m, 26 Dec 1947, *Carter, Alexander & Kellogg 2378* (DS); In granitic rocks at edge of Arroyo del León, N of road from La Paz to Los Planes, 22 mi SE of La Paz, alt ca 1565 ft, 11 Dec 1959, *Wiggins, Carter & Ernst 494* (DS).

This is one of the most widely ranging species among the species of *Selaginella* native to western North America, growing well through nearly 15 degrees of latitude, but mostly on the coastal slopes of the foothills and mountains within its range. It is also remarkable for the lack of variation between and within populations, and for the diversity of the substrata it occupies. It seems to be equally adapted to granitic rocks, to basaltic extrusions, on sandstone, in crevices in serpentine, or gravelly detritus derived from any or all of these basic sources, and even on clay soil where little rock is present. It occurs too, on both north- and south-facing rocky areas if it is within the influence of coastal fog drift, and does well on vertical cliffs, gentle slopes or nearly level areas in shallow depressions.

4. SELAGINELLA CINERASCENS A. A. Eaton, Fern Bull. 7: 33. 1899.

Forming close coverings of clay soil in open areas or among shrubs in coastal areas near San Diego and southward into Baja California.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25 µ
s
t
0.1 mm
ILW

SPECIMENS EXAMINED: **Baja California:** Among chaparral about 20 mi N of Ensenada, along road to Tijuana, 28 Feb 1934, *Ferris 8474* (DS); Ensenada, mostly on hillsides, 7 Apr 1921, *I. M. Johnston 3004* (CAS); about 30 mi S of Tijuana, 13 Mar 1956, *Howell 30937* (CAS); Hillside NE of town of Ensenada, alt 200–400 ft, 23 Feb 1930, *Wiggins 4213* (DS); about 12 mi N of Santo Tomás, along highway, 29 June 1962, *Wiggins & Thomas 416* (DS).

The paucity of specimens of this species in herbaria is doubtless attributable to the difficulty one has in freeing good specimens from the heavy soil on which it grows. When the substrate is moist it requires tedious, time-consuming effort to get the plants separated from the clay, and when dry the earth is so hard that the fragile, closely attached plants are badly broken in the process. Consequently, most collectors ignore the close mats of moss-like growth.

The wide differences in the sizes of leaves found on a plant, as pointed out by Tryon, is not applicable to the leaves taken on the upper and lower surfaces of the stem or branches at the same distance from the apex (or base) of a stem or branch, as indicated by *Plate 24, figs. a–c.*

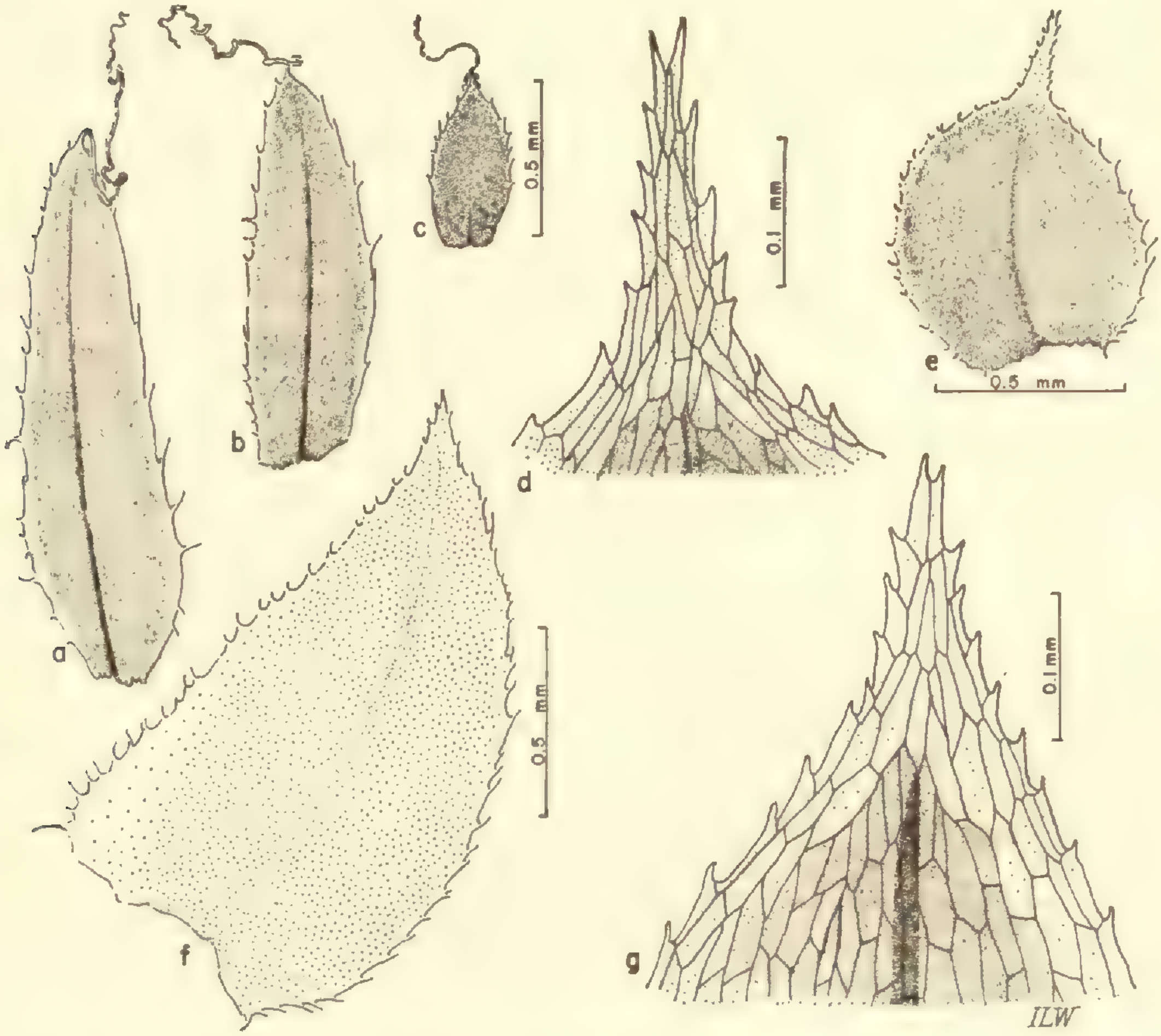
5. SELAGINELLA EREMOPHILA Maxon, Smiths. Misc. Coll. **72**(5): 3, *pl. 2.* 1920.

On shaded sides of rocks in open desert, along ledges and on steep to vertical walls of canyons, and occasionally on gravel at

---

FIGS. a–g, SELAGINELLA CINERASCENS: a = LEAF FROM UNDER SIDE OF PROSTRATE STEM; b, c = REPRESENTATIVE LEAVES FROM UPPER SIDE OF STEM; d = MICROSPOROPHYLL WITH MICROSPORANGIUM INTACT; e = MEGASPOROPHYLL, ABAXIAL FACE; f = MEGASPORE, COMMISSURAL VIEW; g = MICROSPORE, OUTER FACE. FIGS. h–l, SELAGINELLA EREMOPHILA: h = MEGASPORE, OUTER FACE; i = LEAF FROM UPPER SIDE OF DECUMBENT STEM, TERMINAL SETA DETACHED; k = LEAF FROM UNDER SIDE OF STEM, OPPOSITE i, TERMINAL SETA DETACHED; l = MEGASPOROPHYLL, ABAXIAL VIEW. FIGS. m–t, SELAGINELLA LEPIDOPHYLLA: m = TIP OF BRANCHLET VIEWED FROM UPPER SIDE; n = SEGMENT OF SAME BRANCHLET VIEWED FROM UNDER SIDE; o = LEAF FROM UPPER SIDE OF BRANCHLET, AXIS OF BRANCH TO ITS RIGHT; p = LEAF FROM UNDER SIDE OF BRANCHLET OPPOSITE o, AXIS OF BRANCH TO ITS LEFT; q = MICROSPOROPHYLL, ABAXIAL VIEW; r = SMALL STROBILUS AT TIP OF BRANCHLET, VIEWED FROM UPPER SIDE OF DORSIVENTRAL BRANCH; s = MICROSPORE, LATERAL VIEW; t = MEGASPORE, OUTER FACE.

the bases of such rocky areas, mostly below 3,000 feet, western Colorado Desert in California, in the Chuckwalla Mountains,



FIGS. a–c, SELAGINELLA EREMOPHILA: a = NEARLY FULLY DEVELOPED LEAF FROM NEAR APEX OF BRANCHLET; b, c = SUCCESSIVELY YOUNGER LEAVES FROM SAME BRANCHLET, ALL LEAVES STILL BEARING THE FRAGILE, TORTUOUS, TERMINAL SETAE. FIGS. d–g, SELAGINELLA PALLESCENS: d = CELLULAR STRUCTURE OF APEX OF MATURE LEAF FROM UPPER SIDE OF PROSTRATE BRANCHLET; e = LEAF FROM UPPER SIDE OF BRANCHLET; f = MATURE LEAF FROM UNDER SIDE OF PROSTRATE BRANCHLET, ABAXIAL VIEW; g = CELLULAR STRUCTURE OF APEX OF VENTRAL LEAF, ADAXIAL VIEW.

California, and vicinity of Tinajas Altas, southwestern Arizona and south in Baja California about to the vicinity of Bahía de los Angeles.

SPECIMENS EXAMINED: **Baja California:** Near Cantu Grade, 39 mi W of Mexicali, along highway to Alaska and Tijuana, alt ca 2500 ft, 6 Apr 1954,

Wiggins 13045 (DS); Rocky hillside 0.5 mi SW of Rosarito, ca 40 mi SE of San Quintín, SW foothills of Sierra San Pedro Mártir, alt ca 2900 ft, 16 May 1944, *Wiggins 9981* (DS); Lower half of Cañon Diablo, east face of Sierra San Pedro Mártir, near Lat. 31° 2′ N, Long. 115° 25′ W, 22–27 Mar 1954, *Stombler 131* (DS); El Terminal, 16 mi S of Los Angeles Bay, common on N side of rocks near canyon mouth, near Lat. 28° 45′ N, Long. 113° 35′ W, alt ca 400 m, 14 Jan 1962, *Moran 8524* (DS); About 6 mi S of Las Flores, S of Los Angeles Bay, near Lat. 28° 43′ N, Long 113° 32′ W, 13 Feb 1962, *Wiggins & Thomas 272* (DS).

The terminal seta on vegetative leaves of this species is remarkably slender and tortuous. However, this seta is very easily detached, so one rarely finds a leaf bearing a terminal seta except among the incurled, partially expanded young leaves at the very tip of a branchlet. Careful examination of a thoroughly moistened, relaxed branch apex under high magnification (about 30 to 40 ×) usually reveals a few young leaves retaining the hairlike, white seta.

6. SELAGINELLA LEPIDOPHYLLA (Hook. & Grev.) Spring in Mart. Fl. Bras. 1(2): 126. 1840.

Lycopodium lepidophyllum Hook. & Grev. Bot. Misc. **3**: 106. 1832.

On limestone ledges, on talus slopes, in crevices in both calcareous and igneous rocks, on north-facing slopes and shaded sides of boulders at contact between gravelly soil and the rock, from western Texas and New Mexico south through Mexico to El Salvador.

SPECIMENS EXAMINED: **Baja California:** Peninsular divide W of Caduaño, Sierra de la Victoria, Cape Region, alt ca 4000 ft, 11 May 1959, *Thomas 7859* (DS); On north-facing cliff overlooking river at Las Animas Ranch, near base of El Picacho, Sierra de la Laguna, alt ca 2000 ft, 12 Oct 1941, *Hammerly 281* (CAS, DS).

The plants of both this and the following species often are called "Resurrection Plant" owing to the rapidity with which they flatten out and become bright green after being soaked by rain, in striking contrast to the apparently dead, compactly incurled branches during a period of drought. They can survive for months in the dormant condition, with the whole plant rolled into a grayish or brownish ball. The plants of both species are attached to the soil or rock only at the center of the rosette; no rhizophores

appear along the under side of the flattened branches during periods of active growth and photosynthesis. Dead leaves and branchlets from a plant itself, vegetative debris from adjacent plants, dust, and soil accumulate around the bases and within the curled up balls of dry ones. This detritus often complicates the task of making acceptable herbarium specimens.

7. SELAGINELLA PALLESCENS (Presl) Spring in Mart. Fl. Bras. 1(2): 132. 1840.

Lycopodium pallescens Presl, Rel. Haenk. 1: 79. 1825.

Selaginella cuspidata (Link) Link, Fil. Sp. Hort. Reg. Bot. Berol. Cultae 158. 1841.

Around rocks, at bases of cliffs and rocky ledges, on gravelly soil of meadows and in open stands of shrubs, Sonora and Chihuahua, southward in Mexico and Central America into northern South America.

SPECIMENS EXAMINED: **Baja California:** Canyon at La Laguna, Sierra de la Laguna, E of Todos Santos, alt 1650 m, 25 Dec 1947, *Carter, Alexander & Kellogg 2335* (DS); Shaded rock faces along trail to Laguna from W, especially near summit, Sierra de la Victoria, 20 Aug 1955, *Chambers 935* (DS); Potrero de Almerta, Arroyo de Almerta, E slopes of Sierra de la Victoria, inland from Caduaño, among rocks and palms, alt ca 3400 ft, 9–11 May 1959, *Thomas 7816* (DS); Large meadow surrounded by oaks and *Pinus cembroides*, La Laguna, Sierra de la Laguna, alt ca 6000 ft, 16–18 May 1959, *Thomas 7930C* (DS).

Selaginella pallescens is aptly named, for when curled up in the dry condition, the under sides of the branches and the leaves on that side are silvery white, whereas the compact ball of a dry plant of *S. lepidophylla* has a reddish brown to rusty tinge. In both species the leaves on the under side of the branches are considerably longer that those on the upper side, the lower leaves extending appreciably beyond the outer margins of the upper ones. The stoutish, denticulate-scabrous seta at the apex of each leaf in *S. pallescens* contrasts sharply with the merely acute leaf of *S. lepidophylla*, which lacks a seta. This character can be seen easily with a hand lens, or in good light with the naked eye. Thus the two are not at all likely to be confused with one another.

DUDLEY HERBARIUM, STANFORD UNIVERSITY, STANFORD, CA 94305.

Notes on the Ferns of Dominica and St. Vincent, II[1]

C. V. MORTON AND DAVID B. LELLINGER

This paper extends and concludes our notes on Lesser Antillean ferns and is based principally on collections made under the Bredin-Archbold-Smithsonian Biological Survey of Dominica that was active from 1963 to 1969, and also on collections made by C. V. Morton on St. Vincent in 1947. Since the prior report (Morton & Lellinger, 1967) a few more botanists have visited Dominica and further researches by ourselves and others have solved some additional problems of taxonomy and nomenclature.

DIPLAZIUM AMBIGUUM Raddi, Opusc. Sci. Bologna **3:** 292. 1819.

Diplazium radicans sensu Christ, Farnkr. 220. 1896, *pro parte.*

This South American species is known to us in the Antilles only from St. Vincent, where it was collected in the valley of the north fork of the Cumberland River at 400–600 m altitude (*Morton 5469*) and in the upper valley of the Richmond River at 330–540 m altitude (*Morton 6182*). These specimens match an isotype of the species found "in sylvis opacis prope Mandiocam, Brasiliae," *Raddi* (FI, Morton photos 15914–15919 US). *Diplazium ambiguum* closely resembles *D. striatum* (L.) Presl, which is widely distributed in the Antilles. The former species is bipinnate-pinnatifid, at least in most of the lower pinnae, whereas the latter is strictly pinnate-pinnatifid. It also resembles *D. expansum* Willd., but lacks the usually abundant hairs on the lower surface of the costae and costules of that species and has entire, not ciliate-erose, indusia.

Diplazium radicans (Swartz) Desv. is not a synonym of *D. ambiguum*, but is a name based on *Asplenium radicans* Swartz, 1806, *non* L., 1759. (The two other names cited by Desvaux on p. 281 of his "Prodromus" are invalid, later homonyms in *Asplenium*) Under *A. radicans* Swartz, Desvaux cites *t. 76* of Schkuhr's "Kryptogamische Gewächse," a dubious species according to Christensen's "Index Filicum," plus Swartz' original publication

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[1] Partial cost of publication borne by the Smithsonian Institution.

of the species, which is based on one of his own specimens from Jamaica. Judging by Maxon's photograph of this probable holotype and his annotation of the specimen, it is a taxonomic synonym of *Asplenium dayi* Hieron., which is the valid name for this extremely rare Jamaican plant.

ELAPHOGLOSSUM PUSILLUM (Mett. ex Kuhn) C. Chr., Ind. Fil. 314. 1905.

This species has heretofore been known only from the Greater Antilles and from Guadeloupe and Martinique. The first record for Dominica (*Wilbur 8097*) is from the forested slopes just below the summit and from dense thickets on the summit of Morne Trois Pitons, at 4000 4400 ft altitude. It is recorded as a common epiphyte.

ERIOSORUS HISPIDULUS var. DOMINICENSIS A. F. Tryon, Contr. Gray Herb. **200:** 115. 1970.

Chambers 2596, from the summit of Morne Trois Pitons, is the first collection of *Eriosorus* from Dominica. It was collected in a habitat typical for this genus: in a dense growth of pendent moss, on the side of a large, exposed rock at the lower margin of the most dwarfed pigmy forest, at about 4400 ft altitude.

PITYROGRAMMA TARTAREA (Cav.) Maxon, Contr. U. S. Nat. Herb. **17:** 173. 1913.

Proctor (1965, pp. 219–220) has argued that the correct name for this species is *P. ebenea* (L.) Proctor, based on *Acrostichum ebeneum* L. Sp. Pl. 1071. 1753. He lectotypifies this name on the basis of sheet 1245.14 in the Linnaean Herbarium, which represents a small, depauperate specimen of *P. tartarea*. We disagree, and consider *A. ebeneum* to be a synonym of *A. calomelanos* [= *Pityrogramma calomelanos* (L.) Link]. This has been the usual disposition of *A. ebeneum*.

The name *A. ebeneum* originated in a pre-Linnaean dissertation defended by J. B. Heiligtag in Linnaeus' "Amoenitates Academicae." It included several phrase-name synonyms based on material from Jamaica, Martinique, and Brazil, plus a description of a

large specimen apparently agreeing with *P. calomelanos* ("Stipes pedalis & bipedalis") that Linnaeus omitted from the account of *A. ebeneum* in the "Species Plantarum." In that work the protologue is restricted to the following elements:

1. A citation (Amoen. Acad. 1: 272. 1749) with the phrase name "Acrostichum fronde pinnata, pinnis sessilibus oblongis sinuatis, summis brevissimis integerrimis" copied exactly from the "Amoenitates." Of the phrase-name synonyms in the "Amoenitates," all but the two citations of Sloane's names, which are the only ones based on Jamaican material, should be disregarded for reasons set forth below in point 4. Sloane's names, descriptions, and plate are referable to *P. calomelanos*. The plate depicts a small, rather depauperate specimen.

On the other hand, those Sloane descriptions and plate that truly do refer to *P. tartarea* (Voy. Jam. 35, *t. 7, f. 1*. 1707 and Cat. Jam. 21. 1696) are not mentioned by Linnaeus either in the "Amoenitates" or in the "Species Plantarum."

2. A direct reference to Sloane, Cat. Jam. 20. 1696 and to Voy. Jam. 92, *t. 53, f. 1*. 1707, which are the two Sloane references in the "Amoenitates" mentioned above in point 1.

3. A direct reference to Ray, Hist. Pl. Suppl. 83. 1704, which is based on Sloane, Cat. Jam. 20. 1696, and thus also refers to *P. calomelanos*.

4. "Habitat in Jamaicae sepibus humidiusculis," a statement of locality that restricts type material—specimens or literature—to Jamaica. The specimen in the Linnaean herbarium (1245.14) may or may not be a part of the protologue. Although it is annotated "Acrosticum [*sic*] 20. ebeneum" in the hand of Linnaeus, there is no evidence that it is from Jamaica or was in Linnaeus' possession when either the "Amoenitates" or the "Species Plantarum" was written.

The phrase name in the "Amoenitates" that Linnaeus copied in the "Species Plantarum" does seem to apply to *P. tartarea* better than to *P. calomelanos* ("pinnis sessilibus oblongis sinuatis"), and it could apply to the specimen in the Linnaean herbarium. But the more ample description in the "Amoenitates" that Lin-

naeus omitted in the "Species Plantarum" clearly does not refer to the specimen now in the Linnaean herbarium. The fact of this omission and the restriction of the type to Jamaican material indicates that Linnaeus' concept is based primarily on *t. 53, f. 1* of Sloane's "Voyage."

Tryon (1962, p. 60) suggested that Jenman (1886, p. 38) inferentially lectotypified *A. ebeneum* on the Sloane plate. However, Jenman's paper is merely an attempt to identify the Jamaican ferns in Sloane's herbarium; there are no synonymies in taxonomic form. Under *Gymnogramme calomelanos* Jenman places the Sloane phrase name and reference (Hist. Jam. 92, *t. 53, f. 1*. 1707), and adds "Acrostichum ebeneum Linn.—a young plant [of *G. calomelanos*]." This, we believe, was Linnaeus' actual concept.

PTERIS ARBOREA L. Sp. Pl. 1073. 1753.

Hodge (1954, p. 85) lists this species only for the islands adjacent to Dominica, but it has been collected several times on the island at 1000-1800 m altitude (*Hodge 3236* from near Salybia, *Chambers 2535* and *Lellinger 393* from near Pont Cassé, *Lellinger 443* from near Trafalgar Falls, and *Hodge 74* from Lisdara).

The pedate and areolate species of West Indian *Pteris* related to *P. altissima* Poir. have long been confused, and many names have been in use for them. Specimens in the U. S. National Herbarium can be separated easily with the following key:

Fronds mostly 0.5–1 m long; costular areolae 2 (or 3 in large specimens), always parallel to the costa; costular spinules pointed and usually spreading; laminae gray-green ..... *P. altissima* Poir.

Fronds mostly 1–2.5 m long; costular areolae 1 or 2, the distal one, if present, always parallel to the costule, not the costa; costular spinules absent, rudimentary, or weakly developed and usually parallel to the costae; laminae bright green ..... *P. arborea* L.

For the most part, we have seen type fragments, authentic specimens, or sometimes photographs of type specimens of the names we place in synonymy. Under *P. altissima* Poir. we include *P. brevinervis* (Fée) Jenm., *P. bulbifera* Jenm., *P. elata* Agardh, and *P. kunzeana* Agardh. Under *P. arborea* L. we include *P. aculeata* Swartz, *P. crassipes* Agardh, *P. lactuca* Poir. in Lam., *P. longibrachiata* Agardh, *P. multiserialis* Jenm., and *P. regia* Jenm.

The basis of *P. arborea* should be *t. 5* of Plumier's "Tractatus de Filicibus Americanis." (In this same work *t. 11* is sterile material of the same species, but was not cited by Linnaeus.) The other basic reference cited by Linnaeus, *t. 3* of Plumier's "Description de Plantes de l'Amérique," is also part of the protologue of *Polypodium spinosum* L., presumably through a typographical error.

Pteris hartiana Jenm. is a taxonomically distinct species from Trinidad. It has at least three areolae along the costae, one long and the others shorter; as in *P. altissima*, all are parallel to the costa. It differs from *P. altissima* in having 4–6, rather than 2 or 3, rows of areolae between the costae (or costules) and the margin.

LITERATURE CITED

HODGE, W. H. 1954. Flora of Dominica, B. W. I. Part. I. Lloydia **17**: 1–238.

JENMAN, G. S. 1886. On the Jamaica ferns of Sloane's herbarium. J. Bot. Brit. & For. **24**: 33–43.

MORTON, C. V. and D. B. LELLINGER. 1967. Notes on the ferns of Dominica and St. Vincent. Amer. Fern J. **57**: 66–77.

PROCTOR, G. R. 1965. Taxonomic notes on Jamaican ferns. Brit. Fern Gaz. **9**: 213–221.

TRYON, R. M., JR. 1962. Taxonomic fern notes. II. Contr. Gray Herb. **185**: 52–76.

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Two New Tree Ferns from Costa Rica

LUIS DIEGO GÓMEZ

The tree fern flora of Costa Rica is richly represented by some 50 or 55 species of the Cyatheaceae and Dicksoniaceae. Two have been known from Cocos Island (5°30′N, 87°03′W), a Costa Rican possession in the Pacific Ocean some 300 miles southwest of the Punta Burica Peninsula, the southernmost part of Costa Rica. These species, *Cyathea notabilis* Domin and *Trichipteris nesiotica* (Maxon) Tryon (formerly known as *Alsophila notabilis* Maxon and *A. nesiotica* Maxon), occur on the island from sea-level to its highest point, Monte Yglesias, about 900 m altitude. During an eight-week survey of the island's cryptogamic flora, I noticed a tree fern that differed in several respects from the two previously reported species. Further study lead to the conclusion that this is a new species:

CYATHEA alfonsiana Gómez, sp. nov.

Truncus usque ad 1.5 m altus, ca 5 dm diam, apice ut in petiolorum basibus dense paleaceus, paleis oblongo-lanceolatis, bicoloribus, medio rubescenti-avellaneis, marginibus cremaei-albis; foliorum cicatrices obviae; stipites interdum persistentes, supra ut in rhachi canaliculati et pilosi, subtus glabri, spinulis sparsis parvis apice fere rotundis; pneumatophora non obvia; costae primariae supra pilosae, subtus glabrae, secundariae supra pilosae, subtus paleaceae, paleis numerosis parvis appressis citrini-hyalinis membraneis bulliformibus; pili petiolorum supra rhachium costarum costularumque multicellulares ferruginei attenuati crassi rigidi apicem versus curvati; laminae foliorum oblongo-lanceolatae, 1.4 m longae, 80–90 cm latae, bipinnato-pinnatifidae; pinnae basales abrupte reductae, apice pinnatisectae; pinnae 12–15-jugae alternae, 35–40 cm longae, 12–15 cm latae, pinnulis usque 21-jugis alternis vel subalternis, 6–8 cm longis, 2 cm latis, fere ad costam sectis, segmentis usque 14 paribus alternis oblongis, basi paullo constrictis, 7–9 mm longis, 4–5 mm latis, laeviter lobatis, apice subcrenulatis, venis 7- vel 8-jugis, 1 3-plo furcatis; sori inframediales, indusiati. Indusium squamiforme, parvum.

TYPE: Twin Mountains, Upper Wafer Valley, Cocos Island, alt 400 m, *Gómez 3349* (CR; isotypes F, GH).

Holotype of Cyathea alfonsiana (CR). Fig. 1. Medial pinnae. Fig. 2. Medial pinnules. Scale in cm.

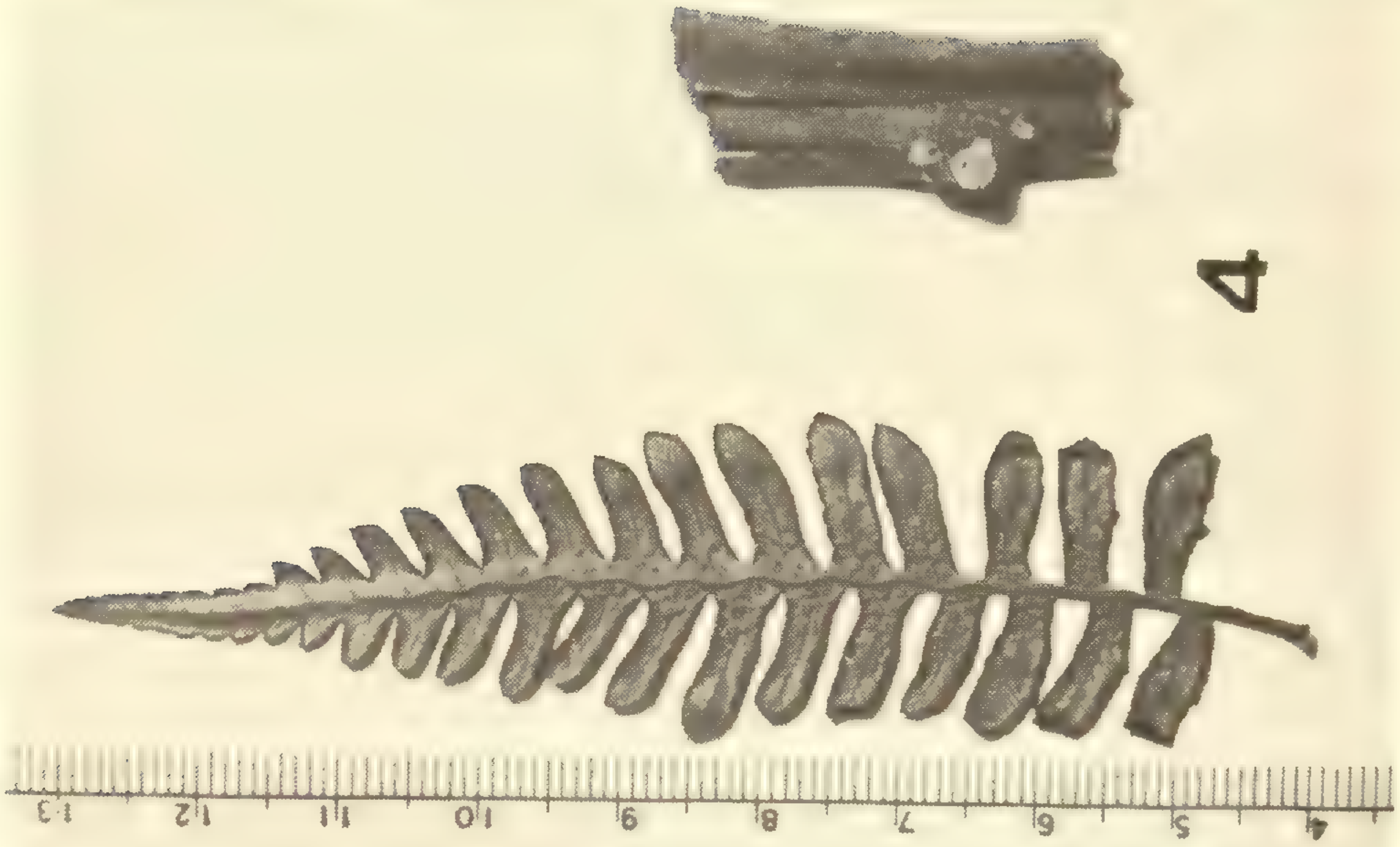
PARATYPES (identity confirmed by R. M. Tryon, Jr.): Cocos Island, *Holdridge 5160* (GH), *W. L. Schmitt 129, 130, 131* (all US).

According to the recent classification of the Cyatheaceae by Tryon (1970), this species falls in *Cyathea*, mainly on the structure of the scales of the trunk, stipe, and rachis; that is, the scales are marginate with a broad margin of cells unlike those of the central portion. The stipe scales lack setae and have, like the rest, a filamentous apex. Various types of indument are present on the stipes, rachises, costae, and costules. The venation is free and there is a scale-like indusium present. The new species differs from *C. notabilis* and from *T. nesiotica* in general habit, but especially in having a scale-like indusium; the indusium is absent in *Trichipteris* and is sphaeropteroid in *C. notabilis*. Such peculiarities of the indusia of these Cocos Island tree ferns were first noted by Maxon in the specimens collected by Schmitt (C. V. Morton, pers. comm.). *Cyathea alfonsiana* is named after Mr. Alfonso Jiménez M., former Curator of the Costa Rican National Herbarium, as a humble tribute to his many contributions to the general knowledge of his country's flora.

The second new species is an endemic fern of the central northeastern slopes of the Talamanca Ridge in continental Costa Rica. This species is in evident danger of extinction due to uncontrolled deforestation. It presents a number of interesting characters, one of them of ecological interest. In collecting some immature sori for chromosome counts, I discovered that a moth of the Nymphalid group deposits its eggs in rows that duplicate exactly the disposition and appearance of the immature sori. All attempts to rear the larvae and adults of this remarkable insect failed, and the moth still remains unidentified. The new species is a conspicuous, tripinnate tree fern also belonging to *Cyathea* in Tryon's classification. It was formerly described, but unfortunately not validly or effectively published, by Nisman (1965) as *Hemitelia holdridgei*, and is here published as:

CYATHEA **holdridgeana** Nisman & Gómez, sp. nov.

Truncus rectus ca 2 m longus, inermis, paleaceus, paleis stramineis ovato-lanceolatis, semiuncialibus, brunneis guttatis. Frons



Holotype of Cyathea holdridgeana (CR). Fig. 3. Medial pinna. Fig. 4. Medial pinnule and part of rachis. Scale in cm.

2 m longa, pinnatisecta. Stipes et rhachis semiteretes canaliculati, ochracei opaci, parce muricati. Stipes 7 cm longus, 1.5 cm crassus, ad basim paleaceus, primo furfuraceus, postea glabrescens; rhachis supra strigosa, subtus furfuracea, paucis paleis sparsis, pinnis 17-jugatis. Pinnae petiolatae (petiolo 2.5 cm longo), rhachibus fere teretibus canaliculatis, dense strigosis, subtus furfuraceis squamulosis, deltoideo-lanceolatis, pinnulis 20-jugatis; laminae apice acuminatae serratae. Pinnulae petiolulatae (4 mm) deltoideo-lanceolatae, segmentis 14-jugatis. Costa dense strigosa; trichomata septata fulva, subtus furfuraceo-squamulosa. Segmenta in basali parte pinnulae distincta, sessilia, ad basim laeve inaequalia. Pars apicalis pinnulae pinnatisecta fere ad costam. Laminae coriaceae, supra glabrae, virides, subtus pallidiores, margine revoluto serrato. Costa secundaria ad basim strigosa, ad apicem cum 2–4 pilis rigidis, subtus squamulosa. Sori inframediales, orbiculares, translucenti-virides, costis secundariis propinqui.

TYPE: La Chonta, at Km 55 of the Interamerican Highway, Prov. Cartago, Costa Rica, alt 2200 m, *Carmen Nisman S. 104* (CR; isotypes F, GH).

PARATYPES: La Chonta, Prov. San José, Costa Rica, alt 2300 m, *Gómez 2542, 2577, 2560, Goldgewicht & Gómez 2675* (all Herb. Gómez); Km 54 of the Interamerican Highway, Costa Rica, *J. A. Saenz* (Herb. Gómez).

Although there are a number of species of *Cyathea* with tripinnate or tripinnate-pinnatifid fronds, such as *C. hemiotis* Christ and *C. hastulata* Christ, the closer affinity of *C. holdridgeana* seems to be with *C. multiflora* J. E. Smith and *C. costaricensis* (Mett. ex Kuhn) Domin, from which it differs in having sessile pinnae, petiolulate pinnules, a strictly inframedial sorus, and bicolorous and corticinate scales on the stipe.

LITERATURE CITED

NISMAN S., CARMEN. 1965. Estudio taxonómico y ecológico de los helechos arborescentes (Cyatheaceae y Dicksoniaceae) de Costa Rica. Lic. Thesis, University of Costa Rica.

TRYON, R. M., JR. 1970. The classification of the Cyatheaceae. Contr. Gray Herb. **200**: 3–53.

MUSEO NACIONAL DE COSTA RICA, APARTADO 749, SAN JOSÉ, COSTA RICA.

Comparative Habitat Requirements for Spore Germination and Prothallial Growth of Three Ferns in Southeastern Michigan

Royce H. Hill[1]

Investigation of the physiological ecology of various plants has yielded information concerning mechanisms and patterns of evolutionary divergence (Björkman & Holmgren, 1963; Ayodele Cole, 1967; Hadley & Levin, 1969; Mooney & Billings, 1961). Such studies have largely omitted pteridophytes. Owing to the alternation-of-generations life cycle, certain problems arise concerning physiological divergence within groups of pteridophytes. The success of pteridophytes in a community is obviously limited both by the successful establishment of free-living gametophytes and the survival of sporophytes. Thus, the habitat requirements for spore germination and prothallial growth are critical factors for the success of the plant. Physiological divergence between populations or species, as a result of selective pressures of ecologically different habitats, should be apparent in both phases of the pteridophyte life cycle.

Farrar (1967) found fern gametophytes reproducing independently in the southern Appalachians, far north of the normal ranges of their sporophytes. Conway (1953) stated that there are few records of finding sporelings of *Pteridium aquilinum* in Scotland, even though the sporophytes are common and spore production is heavy. She suggested that spores are released late during the growing season and that *Pteridium* sporelings are more susceptible to frost than are those of other species observed. Conway also noted that sporelings are subject to attack by soil insects and fungi. These two studies suggest that the gametophytic and sporophytic phases of a plant can have different habitat requirements and that one phase of the life cycle can be

[1] I wish to acknowledge the guidance of Dr. Warren H. Wagner, Jr. and Dr. Edward L. McWilliams and the use of the facilities of the Matthaei Botanical Gardens, University of Michigan.

limiting to the success of the species in extending its geographical range and ecological amplitude.

The purpose of this investigation is to compare the habitat requirements of prothallia of three polypodiaceous species that occupy ecologically contrasting habitats in southeastern Michigan.

METHODS

Species from habitats differing in exposure to sunlight and in substrate pH were selected for study. The habitats are located in Washtenaw County, Michigan. *Thelypteris palustris* Schott (Marsh Fern) grows abundantly on the open sphagnum mat of Mudlake Bog. *Woodwardia virginica* (L.) J. E. Sm. (Virginia Chain Fern) occupies floating, graminoid mats in a swamp clearing at the Waterloo Recreation Area. *Adiantum pedatum* L. (Maidenhair Fern) grows in an upland northern woods at Sharon Hollow.

Light intensity and temperatures were taken at the habitats. Light intensity was measured with a General Electric Type DP-9 light meter and temperatures were taken at 30 cm and at the substrate surface with glass mercury thermometers. Readings were taken at each habitat and at an adjacent, gravel road to obtain habitat and ambient conditions, respectively. The ambient readings were intended to facilitate comparisons of environmental data taken on different days, August 7 at Sharon Hollow and at Waterloo and on August 30 at Mudlake Bog. Both days were bright and hot, as indicated by the similarity of the ambient conditions of the habitats. These data appear in *Table I*.

Spores were collected by washing fertile fronds under running tap water, blotting them dry, and placing them in envelopes for storage for several months at 6° C. Upon removing the spores from storage, they were filtered through a 0.177 mm sieve and several layers of cheesecloth to screen out extraneous material such as sporangia. They were then sown in 10 × 35 mm plastic petri dishes containing nutrient medium, at a density of approximately 100 spores per square cm. The medium was one of several variations of full-strength Bold's nutrient solution. Liquid medium and liquid solution added to blotting paper were usable, but these

techniques often led to fungal or algal contamination of the cultures. Bold's solution solidified with 1% bacto-agar was the medium least susceptible to contamination.

The petri dishes were placed under gradients of light intensity and pH, inside a growth chamber, and of temperature on a thermogradient plate. In the light intensity experiments, the light source was a combination of incandescent and Cool White fluorescent lamps; the petri dishes were placed at varying distances from the light source and/or were covered with layers of cheesecloth in order to vary the light intensity. Temperatures inside the plates were determined with a Telethermometer probe and maintained at $25 \pm 1°C$. Temperature control at the higher values of light intensity was facilitated by placing the dishes in the direct flow of cool air above the chamber vents and by positioning a plexiglass water screen containing 10 cm of water between the dishes and the light source. The pH of the medium was adjusted to 6.7 by adding NaOH or HCl for both the light and temperature experiments. Petri dishes were placed under 500 ft-c at $25 \pm 1°C$ in the pH experiments and under incandescent light at 500 ft-c in the temperature experiments.

After a growth period of 3 weeks, the percentage of germination and prothallial width (to 0.1 mm) were determined, the former based upon 400 spores or prothallia and the latter upon the maximum width of 40 prothallia, measured with an ocular micrometer mounted in a dissecting microscope at 40 ×. Prothallial width was chosen as an index of growth because width increments of gametophytes appeared to be more directly related to increments of prothallial area than were length increments. Dark-grown prothallia in the light intensity experiments, for example, were long and spindly, whereas cordate prothallia at higher light intensities attained somewhat greater prothallial width but only slightly greater length than dark-grown prothallia.

ENVIRONMENTAL DATA

Table I shows that light intensity (LI) was highest in the open habitats. The bog habitat is fully exposed to light except for

occasional shade cast by poison sumac shrubs; the swamp habitat is shaded only during the early morning hours by an upland oak-hickory woods just east of the swamp. LI at the wooded habitat on August 7 varied from 77 ft-c in deep shade to 1192 ft-c where light flecks penetrated the canopy, even though ambient LI (at the road) was 5700 ft-c. *Table I* also shows that the air and surface temperatures, relative to ambient temperatures, were also higher in the open habitats than in the wooded habitat.

Table I shows that the open habitats are acidic, whereas the woodland habitat is circumneutral. The bog—a typical northern

TABLE I. COMPARISON OF THE HABITATS OF THREE FERN SPECIES

Species	*Adiantum pedatum*	*Thelypteris palustris*	*Woodwardia virginica*
Locality	Sharon Hollow	Mudlake Bog	Waterloo
Habitat	wooded upland	open bog	swamp clearing
Light Intensity (ft-c)			
ambient	5700	4556	5479
habitat	77–1192	4300	4552
Temperature (°C)			
ambient (30 cm)	34.0	33.5	35.4
habitat			
30 cm	27.4	31.8	32.0
surface	27.2	30.0	29.8
Substrate	rich humus	sphagnum mat	graminoid mats
Substrate pH	7.6–7.8	5.5	5.9

one—is dominated by sphagnum, larch, and ericaceous shrubs. The swamp substrate is acidic and highly anaerobic. The woodland substrate consisted of leaf litter overlying a deciduous forest mull.

COMPARISON OF GERMINATION TIMES AND GROWTH RATES

Thelypteris and *Woodwardia* spores required about 2 days for germination, whereas *Adiantum* spores germinated in 5 days. The first two species also had faster growth rates than did *Adiantum* during the 3-week period following germination. Prothallial width

of *Adiantum* never exceeded 0.6 mm, whereas that of the other species reached 2.0 mm at the lower pH values. The shorter germination time and faster growth rates of the open-habitat species may constitute an adaptive advantage. It is likely that prothallia of these species would have faster growth rates and be more competitive than would *Adiantum* in an exposed habitat.

TEMPERATURE EXPERIMENTS

Petri dishes of each species were placed on a thermogradient plate to establish a 15–35°C temperature gradient. In addition, dishes were also placed in two cold rooms at 5 and 10°C. As seen in *Fig. 1*, none of the spores germinated at 5°C, although spores did germinate after they were moved to 25°C following their exposure to the cooler temperature. Other experiments showed that none of the spores germinated at 40°C and that the spores lost viability, for they did not germinate when they were moved to 25°C. *Thelypteris* and *Woodwardia* spores germinated at 35°C, but *Adiantum* spores did not.

The temperature limits of germination for *Thelypteris* and *Woodwardia* are approximately 10–35°C, whereas those of *Adiantum* are about 10–30°C. The higher temperature tolerance of the open-habitat species may be considered adaptive, since surface temperatures of the bog and swamp probably reach 30–35°C regularly during the mid-hours of the day. Surface temperatures of the woodland habitat probably seldom reach 30°C. Spores landing on the sphagnum mat of the bog or on the floating mats of the swamp would certainly be exposed to more adverse temperatures than those landing on the forest floor of the woodland habitat.

Figure 1 also shows that optimum or near-optimum temperatures for prothallial growth are higher for the open-habitat species than for *Adiantum*. These were 25–30°C for *Thelypteris*, 25°C for *Woodwardia*, and 15-25°C for *Adiantum*. Prothallial growth of the three species followed much the same pattern as germination, although it can be seen that the temperature limits of germination are broader than those of maximum or near-maximum growth of prothallia. Although spores of *Thelypteris* and *Woodwardia*

germinated at 10°C, prothallial growth was relatively low at temperatures below 25°C. By contrast, *Adiantum* prothallia had relatively high growth rates at 15°C. The preference for lower temperatures in the latter species, as compared to the open-habitat species, appears to be an adaptation to the cooler woodland habitat. Growth of *Adiantum* prothallia, compared to the other species, was decidedly slower and dropped abruptly at temperatures above 25°C. The preference for higher temperatures

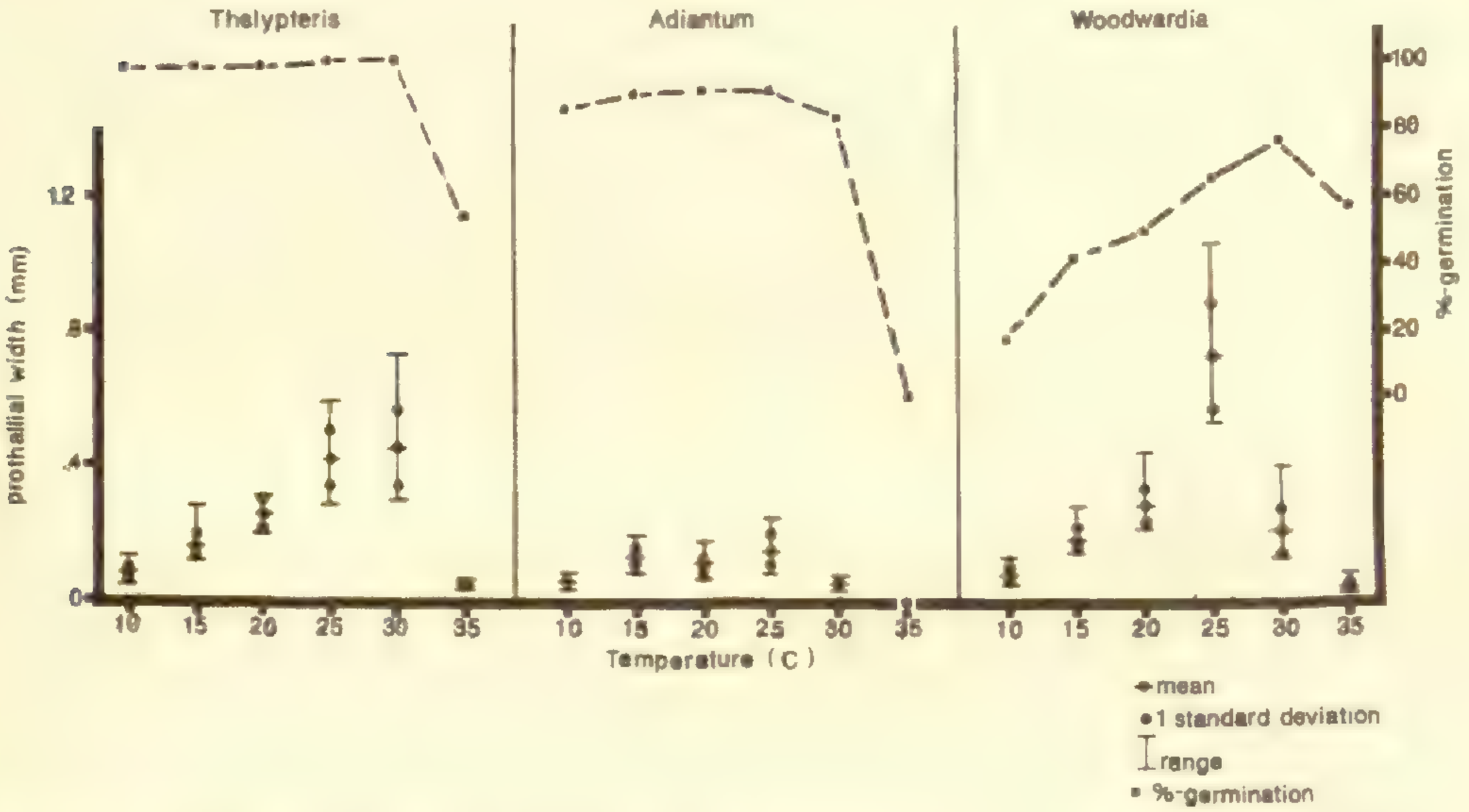


FIG. 1. THE EFFECT OF TEMPERATURE ON PROTHALLIAL WIDTH AND PERCENT GERMINATION OF SPORES.

and the tolerance of higher temperatures in *Thelypteris* and *Woodwardia* appear adaptive to the open habitats of these species. Thus the temperature requirements for prothallial growth of these species are even more in accord with their respective habitat conditions than are their temperature requirements for germination.

The temperature limits of spore germination may be compared with those reported by Hartt (1925) for *Onoclea sensibilis*, in which the spores germinated at 16–34°C with an optimum of 28°C. Spore viability was lost at 40°C. Hevly (1963), in a study of the physiological ecology of cheilanthoid ferns, reported much higher

temperature limits. Spores of *Notholaena cochisensis*, a xerophytic fern that typically grows fully exposed to the sun, germinated at 10–50°C with an optimum of 25–35°C, whereas *Cheilanthes fendleri*, which usually inhabits crevices around the bases of boulders, germinated at 0–35°C with an optimum of 15–20°C.

The spores of the species investigated here germinate in only a few days after sowing, and previous experiments showed that freshly collected spores are fully capable of germinating. These observations suggest that spores would germinate in the field soon after their discharge from sporangia, and that the overwintering stage is the prothallium rather than the spore. Observations of seasonal phenology of these species showed that initial dehiscence of sporangia occurred on June 22 for *Woodwardia*, August 7 for *Adiantum*, and August 25 for *Thelypteris*.

It would seem reasonable that spores shed late in the growing season, such as those of *Adiantum* and *Thelypteris*, would overwinter before germinating. If this were the case, the spores would probably have a chill requirement for germination. This was not found to be the case for these species, but the question of whether spores that fail to germinate during the growing season in which they were discharged *could* survive winter conditions arises. It was noted that the spores retained their viability after several weeks of storage at 6°C and at shorter exposure to 5°C on agar medium. In an attempt to resolve this question, spores were sown in a liquid medium which was then frozen for 30 days and then brought to room temperature. A high percentage of the spores germinated, and in the time periods characteristic for each species. It appears that spores of these species are able to retain viability under winter conditions, although the evidence suggests that the usual overwintering stage is the gametophyte rather than the dormant spore. These are only tentative observations and need to be followed by intensive field studies.

LIGHT INTENSITY EXPERIMENTS

A LI gradient of 100–3000 ft-c was established. In addition, petri dishes were covered with black cloth, after receiving an

initial light stimulus during sowing, to effect dark conditions. Germination percentages and prothallial growth for the species over the gradient are shown in *Fig. 2*.

Although spores of all species germinated at all LI values, the percentage of germination was lower in darkness and high germination rates were reached at 100–3000 ft-c for all three species.

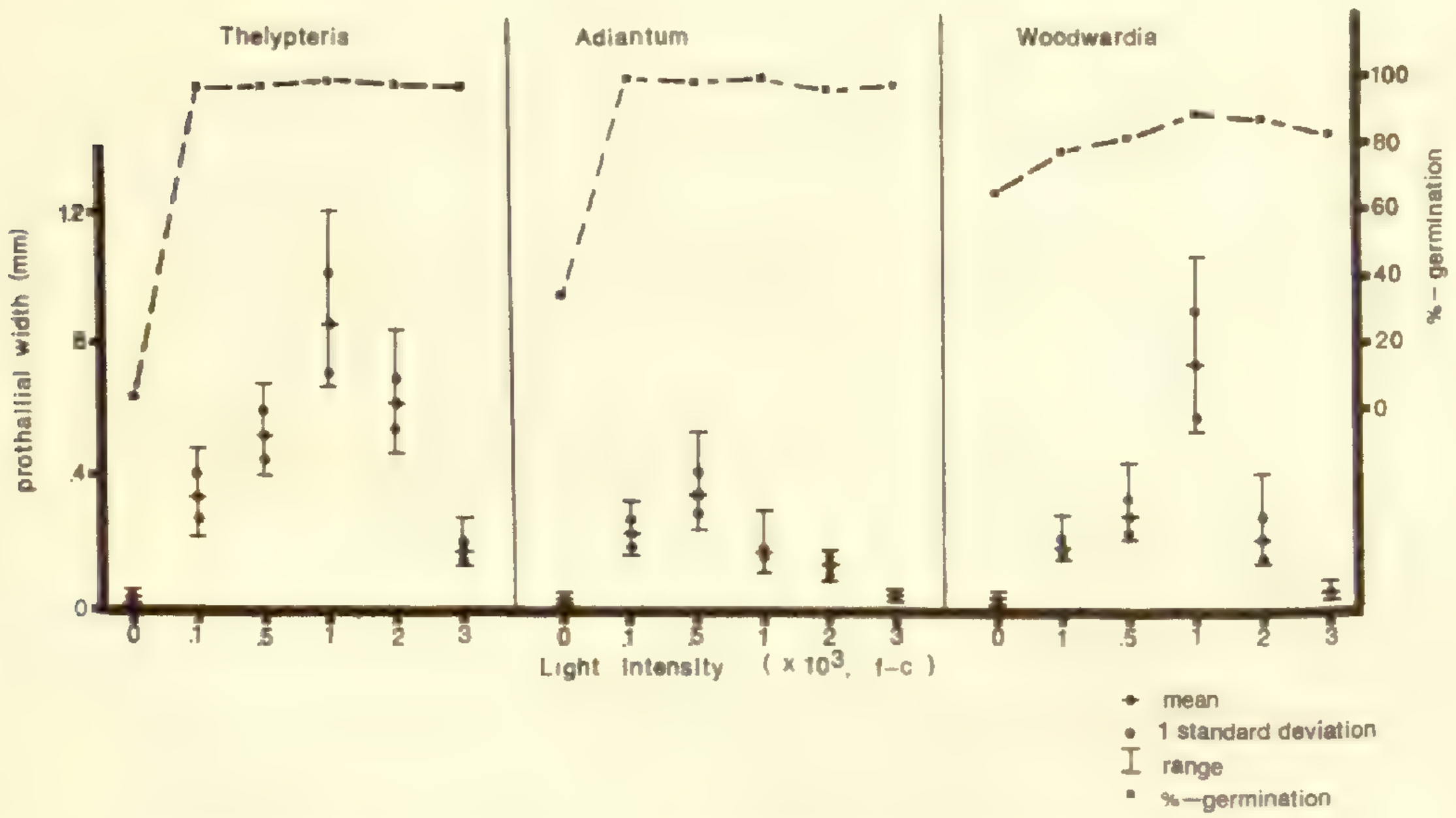


FIG. 2. THE EFFECT OF LIGHT INTENSITY ON PROTHALLIAL WIDTH AND PERCENT GERMINATION OF SPORES.

The prothallia of all three species were long and spindly when grown in darkness. The prothallial width of *Thelypteris* was greatest at 1000 ft-c, and that of *Woodwardia* and *Adiantum* at 500 ft-c, but prothallial growth dropped off more abruptly at values above 500 ft-c in *Adiantum* than in the open-habitat species. The relatively faster growth rates of the open-habitat species, as compared to those of *Adiantum*, suggest their selective advantage in establishment in open communities.

The apparent chlorophyll levels of prothallia also indicate that the open-habitat species have higher tolerance to high LI than does *Adiantum*. Spores of all three species germinated at 3000 ft-c,

but the resulting prothallia were chlorotic as well as small. At 2000 ft-c, prothallia of *Thelypteris* and *Woodwardia* were pale green, whereas those of *Adiantum* were devoid of green color. Darker green colors were found in all three species at 100 -500 ft-c.

Spores of all three species germinated in darkness after an exposure of only a few seconds to the fluorescent light used during sowing. Mohr (1963) stated that light is an almost universal requirement of spore germination and prothallial development among ferns. Borthwick et al. (1952) noted that certain small seeds require a dose of red light for germination, a stimulus that can be nullified by a subsequent treatment with a far-red light. To determine whether spores of the species under study have no light requirement for germination, or whether the brief exposure of the spores during sowing to fluorescent light (including red light) satisfied a possible light requirement, spores were sown under neutral light only (absence of red light) and then placed in darkness After a period of two weeks, no spores had germinated, indicating a red-light requirement of these spores. It is likely that the germination of these species is under operation of a red and far-red reversible photoreaction.

Du Buy and Neurnbergk (1938) state that *Pteridium aquilinum* spores germinate well in light of "high intensity." This is in accord with results reported here for *Woodwardia* and *Thelypteris*, but Hevly (1963) found that desert ferns of the Southwest germinated at a somewhat lower maximum LI. Miller and Miller (1961) found that prothallia of *Onoclea sensibilis* grew much more rapidly under 400 ft-c than under 220 or 28 ft-c. It was also observed in the present study that prothallia of all three taxa grew faster at 500 ft-c than at lower LI values.

pH EXPERIMENTS

Spores were placed in a pH gradient of 4–10 (*Fig. 3*). *Thelypteris* and *Woodwardia*, which grow in acid habitats, showed lower pH requirements than did *Adiantum*, whose woodland habitat is circumneutral. Spore germination of *Thelypteris* was high over the entire gradient, but prothallial growth showed a marked pref-

erence for pH 5 and decreased sharply at higher pH values. Assuming that the germination process is adapted to the natural habitat of this species, this is in agreement with the observed pH value of 5.5 for water squeezed from sphagnum of Mudlake Bog. *Woodwardia*, whose habitat substrate pH was determined to be 5.9, had both the highest percentage of germination and the

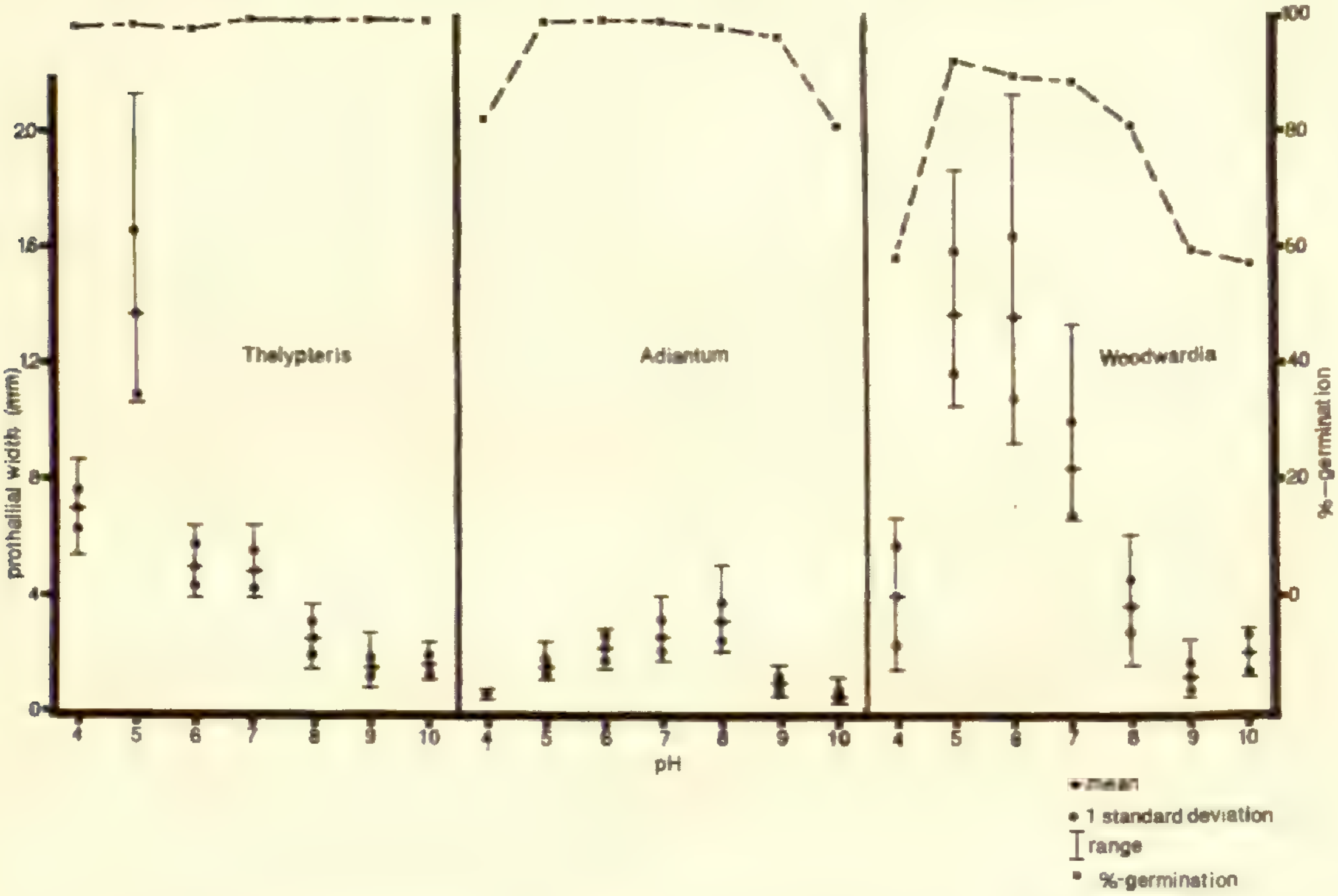


FIG. 3. THE EFFECT OF pH ON PROTHALLIAL WIDTH AND PERCENT GERMINATION OF SPORES.

fastest growth rates at pH 5–7. Percent-germination for *Adiantum*, whose soil pH was 7.6–7.8 in several samples, was high at all pH values except pH 4, and prothallial growth was maximal at pH 8. Again these species differences appear to reflect habitat differences.

Fig. 3 shows that maximum prothallial width of *Thelypteris* and *Woodwardia* exceeded 2.0 mm at low pH values, whereas prothallia of these species grown in the temperature and LI experiments were smaller. This is probably a result of the pH (6.7) used in the latter experiments, which is higher than the optimum

pH values for these species. The comparative growth rates of these three species are also very apparent in the pH experiments, as prothallia of *Adiantum* at optimum pH (8) reached a maximum of only 0.5 mm in diameter. This contrast dramatically demonstrates the faster inherent growth of the open-habitat species as compared to *Adiantum*.

It has been accepted for some time that fern species have definite habitat requirements for substrate pH. Wherry (1920) listed pH ranges for several rock ferns, and Kruckeberg (1964) reported that certain fern species of the Pacific Northwest are restricted to localized ultramafic rocks. It is reasonable that gametophytes have pH requirements similar to those of the sporophytes. McMillan et al. (1968) attributed the narrow distribution of *Pilularia americana* in Texas partially to the inability of spores to germinate on limestone soils. Spore germination of this species was inhibited at pH values above 6.4, although sporelings transplanted to limestone soils grew at normal rates. The habitat of *Pilularia* in central Texas has a pH of 5.2–6.1.

Hevly (1963) found a correlation between the pH of habitats of certain cheilanthoid ferns and their corresponding pH requirements of germination. *Notholaena cochisensis*, which grows on limestone soils, germinates at pH 7–9 with an optimum of pH 8. *Notholaena grayi* germinates at pH 5–8 with an optimum of pH 6 and grows on soils on igneous rock.

The different pH requirements of the open-habitat species and *Adiantum*, like the different temperature and LI requirements of these species, reflects the different habitat conditions of these species. These observations provide strong evidence that the processes of spore germination and prothallial growth of these species, as a result of variation and selection, have undergone physiological divergence.

LITERATURE CITED

AYODELE COLE, N. H. 1967. Comparative physiological ecology of the genus Eriogonum in the Santa Monica Mountains, Southern California. Ecol. Monogr. **37**: 1–24.

BJÖRKMAN, O. and P. HOLMGREN. 1963. Adaptability of the photosynthetic apparatus to light intensity in ecotypes from exposed and shaded habitats. Physiol. Plant. **16**: 889–914.

BORTHWICK, H. A. ET AL. 1952. A reversible photoreaction controlling seed germination. Proc. Nat. Acad. Sci. **38**: 662–666.

CONWAY, ELSIE. 1953. Spore and sporeling survival in Bracken (Pteridium aquilinum (L.) Kuhn). J. Ecol. **41**: 289–294.

DU BUY, H. G. and E. L. NEURNBERGK. 1938. Growth, tropisms, and other movements, Chapter X *in* Manual of Pteridology, ed. F. Verdoorn. M. Nijhoff, The Hague.

FARRAR, D. R. 1967. Gametophytes of four tropical fern genera reproducing independently of their sporophytes in the southern Appalachians. Science **155**: 1266–1267.

HADLEY, E. B. and D. A. LEVIN. 1969. Physiological evidence of hybridization and reticulate evolution in Phlox maculata. Amer. J. Bot. **56**: 561–570.

HARTT, CONSTANCE E. 1925. Conditions for germination of spores of Onoclea sensibilis. Bot. Gaz. **79**: 427–440, *pl. XXIX*.

HEVLY, R. H. 1963. Adaptations of cheilanthoid ferns to desert environments. J. Ariz. Acad. Sci. **2**: 164–175.

KRUCKEBERG, A. R. 1964. Ferns associated with ultramafic rocks in the Pacific Northwest. Amer. Fern J. **54**: 113–126.

MCMILLAN, C. ET AL. 1968. Factors influencing the narrow restriction of Pilularia americana in Texas. Southw. Nat. **13**: 117–127.

MILLER, J. H. and P. M. MILLER. 1961. The effect of different light conditions and sucrose on the growth and development of the gametophyte of the fern, Onoclea sensibilis. Amer. J. Bot. **48**: 154–159.

MOHR, H. 1963. The influence of visible radiation on the germination of archegoniate spores and the growth of the fern protonema. J. Linn. Soc. London, Bot. **58**: 287–296.

MOONEY, H. A. and W. D. BILLINGS. 1961. Comparative physiological ecology of arctic and alpine populations of Oxyria digyna. Ecol. Monogr. **31**: 1–29.

WHERRY, E. T. 1920. The soil reactions of certain rock ferns. I, II. Amer. Fern J. **10**: 15–22, 45–52.

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The Gametophyte of Thelypteris erubescens

LENETTE R. ATKINSON

Thelypteris erubescens, the Reddening Thelypteris, is a fern of the mountains with a thick, creeping rhizome and a leaf that can be 6 feet tall or more. The stipe and large veins may be purplish-tawny (Beddome, 1892, p. 289) or wine-red when dried (Ching, 1963, p. 320). It is one of a small group of ferns in North India and West China and has been known for some time. Iwatsuki (1965, p. 178) in his study of the thelypteroid ferns says of it, the "distinctness of this large and handsome fern has been recognized by various authors since Wallich (1828) gave this name to his Nepalian specimen." Ching (1963, p. 320), who had examined the Wallichian collection (see Ching, 1936, p. 294), says "It has been long noted that of all the Chinese thelypteroid ferns, the well-known exindusiate *Dryopteris erubescens* (Wall.) C. Chr. from the China–Himalayan region always appears to be foreign among all the known genera, in none of which can it possibly fit." Wallich called it *Polypodium*; other authors, depending on which characters were thought to be more important, have placed it in *Glaphyropteris*, *Phegopteris*, *Nephrodium*, and *Dryopteris*. Those who today would place this fern in Christensen's tropical American subgenus *Glaphyropteris* (on the basis of habit and aerophores present) would do so against Christensen's (1913, p. 158) judgement. In discussing his new subgenus *Glaphyropteris* he says "I do not know any Old-World's species which can safely be referred hereto. The Himalayan *D. erubescens* (Wall.) C. Chr. is similar in habit but otherwise quite different." Ching (1963, p. 320) concurred and placed it in his newly created genus *Glaphyropteridopsis*, the type species of which is *Thelypteris erubescens*. The chromosome number reported for this fern by Mitui (1968, *Lastrea erubescens*) is $n = 72$ (on the base 36, one of the more common of the various numbers reported for the Thelypteridaceae). The gametophyte also shows the general characteristics of the group.

I am indebted to Dr. R. E. Holttum for spores of *Thelypteris*

erubescens (Wall. ex Hook.) Ching from a plant from Nepal growing at Kew Gardens, England. Dr. Holttum writes me that this "Kew plant . . . was much smaller than the size to which plants of *erubescens* commonly attain." He continues, "In the Kew herbarium are several quite small specimens, much like that from which your spores came and also some very much larger, with pinnae to 35 cm. long and 3 cm. wide. There are also some rather intermediate in size." The gametophytes were grown under fluorescent light on Knop's solution solidified with agar (Atkinson, 1970).

The bilateral spores are brown singly, black in mass and measure about 33 × 21.5 μ, exclusive of the spore coat. They are ornamented by more or less discrete little wings which when dried are sharp-pointed and give the spore a shaggy or spiny appearance. A colorless rhizoid emerges first at germination. A 4–6-celled filament is formed whose cells may be greatly elongated when developed from spores retained and germinating within the sporangium. The first division initiating the cell plate is usually oblique in the terminal cell of the filament; occasionally it is vertical and in the subterminal cell. A cordate thallus is formed by the activity of an apical cell which may be replaced by an apical meristem as early as a month after germination. The margins of a month old thallus are wavy and may bear 0–3 hairs. At two months simple hairs may also be found on the surface. The thallus bears sex organs by 3.5 months, has a broad cushion and large wings with irregular margins. At 6 months the wings are very large, with folds in the surface and shallowly notched margins. Regeneration in older thalli takes place from the margins of the wings, and little groups of cells project irregularly from the sides of the cushion on the ventral surface. These may bear glandular hairs and abortive antheridia, and are interpreted as regenerative outgrowths.

The first hairs are simple, chlorophyllous and marginal. They are late in appearing; some cordate thalli at one month do not have any hairs. They become glandular and the secretion is yellow. At 2 months they appear on the surface near the notch but are not abundant in either position; one thallus with 2 surface hairs had none on the margin.

The rhizoids are colorless or palest tan, long but do not tangle, and are abundant on the cushion, hiding the older sex organs. When thalli overlap in culture, rhizoids are often borne over the lower part of the cushion on the dorsal surface.

The sex organs are of the advanced type. Archegonia appear at 2 months and embryos at 3.5 months, although no effort was made to produce them. Antheridia are scarce, and those first seen were on separate, usually smaller thalli. At 6 months they appear also at the sides of the cushion beside the opened and younger archegonia. Dehiscence was not observed.

The large, green thallus with simple, yellow glands, ruffled wings, abundant colorless or pale tan rhizoids, and sex organs of the advanced type is not out of place among the gametophytes of the Thelypteridaceae, but it may also be found elsewhere among the ferns. The spore is not very large (as is sometimes the case with polyploids), but, then, spore size at the species level may not always accompany an increase in chromosome number, as Bir (1966) has reported for some Himalayan ferns. Dr. Holttum suggests that a field study of *Thelypteris erubescens* is desirable in a place where the species grows abundantly.

No notable gametophytic features are observed in *Thelypteris erubescens* to suggest relationships to other ferns within the family.

LITERATURE CITED

ATKINSON, LENETTE R. 1970. The gametophyte of Pleocnemia conjugata and of Arcypteris irregularis. Phytomorphology 20: 78–83.

BEDDOME, R. H. 1892. Handbook of the ferns of British India. Calcutta.

BIR, S. S. 1966. Correlation between spore-size and polyploid-level in the Himalayan asplenioid and athyrioid ferns. J. Palynology 2: 41–48.

CHING, R. C. 1936. A revision of the Chinese and Sikkim-Himalaya Dryopteris with reference to some species from neighboring regions. Bull. Fan Mem. Inst. Biol. 6: 237–347.

———. 1963. A reclassification of the family Thelypteridaceae. Acta Phytotax. Sin. 8: 289–335.

CHRISTENSEN, C. 1913. Monograph on the genus Dryopteris I. K. Danske Vidensk. Selsk. Skr. VII, 10: 55–282.

IWATSUKI, K. 1965. Taxonomy of the thelypteroid ferns with special reference to the species of Japan and adjacent regions. IV. Enumeration of

the species of Japan and adjacent regions. Mem. Coll. Sci. Univ. Kyoto, B, **31**: 125–197.

MITUI, K. 1968. Chromosomes and speciation in ferns. Sci. Rep. Tokyo Kyoiku Daigaku, B, **13**: 285–333.

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Shorter Notes

A RECENT FIND OF ISOËTES IN LOUISIANA.—A population of about two dozen plants of *Isoëtes melanopoda* Gay & Dur. has been discovered in Calcasieu Parish, Louisiana. This is the first collection of *Isoëtes* in the state since the 1939 collections of Brown and Lenz, and only the fourth collection of the species in Louisiana. Brown and Correll[1] reported three sites, one each in Avoyelles, East Baton Rouge, and Rapides Parishes. The nearest to ours is in Rapides Parish, approximately 75 miles northeast of Lake Charles. Correll[2] reported *I. melanopoda* f. *pallida* (Engelm.) Fern. in Harris County, Texas, approximately 150 miles west of Lake Charles.

The plants we found grew with sedges in the marginal zone of a depression in a meadow. The plants have sporophylls about 20–30 cm long, and all the collected specimens were fertile. These specimens have pale leaf bases, rather than the dark brown to blackish brown leaf bases of the typical form. Voucher specimens (*J. Brooks & R. Maples 817*) have been deposited at McNeese State University and the University of Southwestern Louisiana.—JAMES H. BROOKS AND ROBERT S. MAPLES, JR., *McNeese State University, Lake Charles, LA 70601.*

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[1] BROWN, C. A. and D. S. CORRELL. 1942. Ferns and Fern Allies of Louisiana. L.S.U. Press, Baton Rouge.

[2] CORRELL, D. S. 1956. Ferns and Fern Allies of Texas. Texas Res. Foundation, Renner.

JAMESONIA ALSTONII IN OAXACA, MEXICO.[1]—The excellent monograph by A. F. Tryon,[2] treating all of the species of *Jamesonia*, gives the northernmost station for the species *J. alstonii* and for the genus as Volcán Tacaná, which is on the border between Guatemala and the state of Chiapas in Mexico. While on a bryological foray into the Sierra Juárez, the authors encountered among the grasses and herbs under scattered trees of *Pinus rudis* a fern which was not immediately recognized. Eventually the senior author realized that it was a *Jamesonia*. He tentatively identified it as *J. alstonii*, an identification kindly confirmed by Dr. John T. Mickel of The New York Botanical Garden. The fern was collected in the highest gap on the road between Oaxaca city and Tuxtepec, Oaxaca, at ca 9000 ft altitude, on 26 December 1970 (*Sharp & Webster 720A*, NY, TENN).

The occurrence of this fern at this station is of interest not only because it represents an extension of its range well into Mexico, but also because this is a locality from which bryophytes of geographical significance have been collected. *Gymnomitrium laceratum*, originally described from Japan but also known from the Great Smoky Mountains, Peru, and southeastern Africa, was reported there by Sharp and Hattori.[3] *Conostomum pentastichum* was also reported from the same station by Bowers and Sharp;[4] except for Mexico and Costa Rica, it seems to be restricted to the southern hemisphere. The senior author also has collected the rather rare *Guamatela tuerckheimii* Donn. Smith (Rosaceae), originally described from Guatemala, below this gap on the eastern slope. It seems that this area is of great significance in providing valuable phytogeographical data.—A. J. SHARP and H. J. WEBSTER, *Department of Botany, University of Tennessee, Knoxville, TN 37916.*

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[1] Contribution from the Botanical Laboratory, University of Tennessee, N.S. 365, and from the Itasca Biology Session, University of Minnesota.

[2] Tryon, Alice F. 1962. A monograph of the fern genus Jamesonia. Contr. Gray Herb. **191**: 109–197, *f. 1–20*.

[3] Sharp, A. J. & S. Hattori. 1967. The range of Gymnomitrium laceratum extended to Mexico. Misc. Bryol. Lich. **4**: 105–106.

[4] Bowers, F. D. & A. J. Sharp. 1968. Conostomum pentastichum in Costa Rica and Mexico. Rev. Bryol. Lich. **36**: 243–244.

Recent Fern Literature

A MONOGRAPH OF THE FERN GENUS ERIOSORUS, by Alice F. Tryon. Contr. Gray Herb. **200:** 54–174. 1970.—Alice Tryon has produced a model monograph of *Eriosorus*, the result of many years of painstaking work. She has studied the cytology, the gametophytes, the anatomy and morphology in detail; she has studied the plants in the field in Costa Rica, Brazil, Puerto Rico, Columbia, and Peru; in addition she has visited Europe several times and has seen most of the historic types. The taxonomic work can therefore be considered definitive. Although there are a few novelties described the general result has been to reduce many of the described species to synonymy. The perhaps controversial part of the work is the recognition of several plants as hybrids with the genus *Jamesonia*. This is reasonable in the case of *Eriosorus elongatus* (Grev. & Hook.) Copel., which is considered a hybrid between *E. cheilanthoides* and *Jamesonia*. These plants do grow together in Andean páramos, and *E. elongatus* does appear somewhat intermediate in morphology. The matter is not so clear in the hybrids indicated as *E. hispidulus* × *Jamesonia*, which seem to show little *Jamesonia* influence. Some other doubtful plants are mentioned as variants, and so it seems that even in the case of a definitive monograph there will always remain some unanswered questions.—C.V.M.

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Errata

Page 30, line 14: For "*Lindheimer*" read "*Lindheimeri.*"
Page 46, line 1: For "MONTGONERY" read MONTGOMERY."
Page 53, line 9: For "*ensifolia*" read "*ensifolium.*"

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